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FINAL

FEASIBILITY STUDY

CD LANDFILL
NAVAL BASE, NORFOLK, VIRGINIA

CONTRACT TASK ORDER 0138

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DEPARTMENT OF THE NAVY
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LIST OF ACRONYMS AND ABBREVIATIONS

ARARs	applicable or relevant and appropriate requirements
AWQC	ambient water quality criteria
Baker	Baker Environmental, Inc.
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
COMNAVBASE	Commander, Naval Base
COPC	contaminant of potential concern
CWA	Clean Water Act
DON	Department of the Navy
ESE	Environmental Science and Engineering, Inc.
ESI	Expanded Site Investigation
F&R	Froehling and Robertson, Inc.
FS	Feasibility Study
gpd/ft	gallons per day per foot
gpm	gallons per minute
HI	hazard index
HRSD	Hampton Roads Sanitation District
IAS	Initial Assessment Study
ICRs	incremental cancer risks
LANTDIV	Atlantic Division Naval Facilities Engineering Command
LDR	land disposal restriction
MCLGs	maximum contaminant level goals
MCLs	maximum contaminant levels
mg/kg	milligrams per kilogram
μg/g	micrograms per gram
μg/L	micrograms per liter
NAS	Naval Air Station
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEESA	Naval Energy and Environmental Support Activity
NEX	Naval Exchange Complex
NOB	Naval Operating Base
NPW	net present worth
O&M	operation and maintenance

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

PA/SI	Preliminary Assessment/Site Inspection
PCBs	polychlorinated biphenyls
POTW	publicly owned treatment works
ppm	parts per million
PRAP	Proposed Remedial Action Plan
RAB	Restoration Advisory Board
RAOs	remedial action objectives
RCRA	Resource Conservation and Recovery Act
RD/RA	Remedial Design/Remedial Action
RI	Remedial Investigation
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SPNC	Sewell's Point Naval Complex
SVOCs	Semivolatile Organic Compounds
TBC	to be considered
TCL	target compound list
TCLP	toxicity characteristic leaching procedure
TMV	toxicity, mobility, or volume
TOC	total organic carbon
TOX	total organic halogens
USEPA	United States Environmental Protection Agency
USGS	United States Geologic Service
VDWM	Virginia Department of Waste Management
VOCs	volatile organic compounds
VR	Virginia Regulations
VWCB	Virginia Water Quality Board

1.0 INTRODUCTION AND PURPOSE

This report presents the Feasibility Study (FS) for the CD Landfill Site, Norfolk Naval Base. This FS has been prepared by Baker Environmental, Inc. (Baker) under contract to the Atlantic Division Naval Facilities Engineering Command (LANTDIV), Contract Number N62470-89-D-4814. The development of this report is based on the scope of work for Contract Task Order Number 0138.

This FS has been conducted according to the basic methodology outlined in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) for Remedial Investigations/Feasibility Studies (RI/FS) (40 CFR 300.430). These NCP regulations were promulgated under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), commonly referred to as Superfund, and amended by the Superfund Amendments and Reauthorization Act (SARA) signed into law on October 17, 1986. The EPA document Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (USEPA, 1988b) was used as a guidance document for preparing this report.

The FS has been based on existing data collected during various studies conducted at Norfolk Naval Base by the Department of the Navy (DON), Baker, and other DON consultants. Site-specific information for this report was obtained from the following documents:

- Draft Final Remedial Investigation Report, CD Landfill, Norfolk Naval Base, Norfolk, Virginia, Baker Environmental, July, 1995.

- Final Feasibility Study, Camp Allen Landfill, Norfolk Naval Base, Norfolk, Virginia, November, 1994.

Volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), pesticides, polychlorinated biphenyls (PCBs) and metals have been confirmed as present in surface water, sediment, surface soils, subsurface soils, and groundwater samples collected in the vicinity of the CD Landfill. In addition, selected radionuclides have been confirmed as present in soil and groundwater samples. In general, this contamination is attributed to past disposal practices in the vicinity of the CD Landfill Site, with the exception of the radiological samples results which appear to be indicative of natural origin. The CD Landfill Site and the surrounding areas are illustrated in

Figure 1-1. The results of the RI and risk assessment indicate that there are potential risks to human health associated with certain media at the CD Landfill Site under several future exposure scenarios. Additional information on RI results and the risk assessment is presented in Sections 1.2, 1.3, and 1.4.

This FS addresses the following contaminated media at the CD Landfill Site:

- surface water
- sediment (shallow and deep)
- surface soil
- subsurface soil
- groundwater

It should be noted that the adjacent inert chemical and asbestos landfill, and any other potential contamination sources or contaminated media, were not considered or addressed in this FS.

The purpose of this FS is to evaluate remedial alternatives that will protect the public health, welfare, and the environment from potential risks associated with contaminated media at the CD Landfill Site.

1.1 <u>Base/Site History</u>

1.1.1 Naval Base Norfolk History

On June 28, 1917, 474 acres of land were acquired by Presidential Proclamation to establish the Sewell's Point Naval Complex (SPNC) to support the war effort. Construction of facilities began on July 4, 1917. On October 12, 1917, the Naval facilities were officially commissioned as the Hampton Roads Naval Operating Base (NOB). In order to fulfill the NOB mission, bulkheads were built from 1917 to 1918 in the waters along the coast to extend available land. After dredge and fill operations, the total land under Navy control was increased from 474 to 792 acres. An additional 143 acres were acquired in 1918 and officially commissioned for the Naval Air Station (NAS).

The post-World War I period was one of decreased naval operations and of economic depression. Few physical changes to the facility occurred between 1920 and 1935. From 1936 to 1940, improvements to the piers and expansion of supplies and materials handling facilities were completed. During this time, the area of the Naval Base expanded to over 2,100 acres because of the involvement of the United States in World War II.

After World War II, naval operations again declined; many ships were decommissioned and crews were discharged. Administrative reorganization of the Navy according to peacetime needs resulted in the establishment of Naval Base Norfolk. Naval Base Norfolk comprised several major components of the former NOB and other Hampton Roads facilities.

The evolution of naval hardware has necessitated many changes since 1960. Facilities to provide support and maintenance for the primary tools of naval operation including aircraft carriers, guided-missile cruisers, and helicopters were the main projects. Rehabilitation of hangars, taxiways, runways, and air traffic control facilities, as well as waterfront construction of several piers, also increased the capability to fulfill the Commander, Naval Base (COMNAVBASE) mission. The mission of COMNAVBASE is to provide fleet support and readiness for the Atlantic Fleet. The mission is four-fold: to command assigned naval shore activities; to coordinate support to afloat units, their air arm, and other naval activities on the naval base complex; to act as regional area coordinator; and to act as senior officer present afloat for administration in the Hampton Roads area.

During its history, Naval Base Norfolk has expanded to become the world's largest naval installation, with 105 ships homeported in Norfolk. The Base currently has 15 piers handling 3,100 ship movements annually. COMNAVBASE supports 20 tenant commands located on the Atlantic Fleet compound.

1.1.2 Site History

The area known as the CD Landfill is located south of Admiral Taussig Boulevard between the Naval Air Station and Hampton Boulevard, Norfolk Naval Base. Originally, the area was part of the historic Bousch Creek drainage system. Prior to 1974, the land was owned by the Western Railway Company and operated as a rail yard.

The Navy purchased the land in 1974. The site incorporates two areas of landfilling operations; the eastern (unpermitted) section and the western (permitted) section. Figure 1-2 shows the area of landfill operations. The eastern (unpermitted) portion of the landfill was filled first and was used for disposal of demolition debris and inert solid waste, fly ash, incinerator residue, chemicals, and asbestos material. From 1974 to 1979, ash residues, sandblasting grit and spent rice hulls were deposited in the unpermitted landfill.

In 1979, a portion of the southeast corner of the site was removed and regraded to allow for runway expansion at the Naval Air Station. The runway expansion design specified that material was to be spread over the landfill and not removed from the site.

In October 1979, the Naval Facilities Engineering Command received a permit from the Virginia Department of Health to use the landfill (western portion) for disposal of demolition debris and other non-putrescible wastes excluding fly ash, incinerator residues, chemicals, and asbestos. Blasting grit used for sandblasting cadmium-plated aircraft parts was deposited at the landfill until 1981 when the blasting grit was tested and found to exceed the EP toxicity limit for cadmium. The grit was classified as a hazardous waste, and on-site disposal of the material ceased. Landfilling operations continued in the western portion of the site until 1987.

Two other known disposal sites (inert chemical landfill and asbestos disposal area) are located adjacent and south of the area of study, beneath the long-term vehicle storage yard. Disposal activities at these sites were reported to have taken place on June 25 and 27, 1979.

Upon closure, the site surface consisted of a thin soil cover vegetated with a variety of grasses to minimize surface erosion. The elevation of the western portion of the landfill was approximately three to five feet higher than the access roadways which surrounded the site. Large mounded areas of soil and debris were located in various portions of the site.

In April 1993, construction began on a new roadway (Seabee Road) across the CD Landfill to link Hampton Boulevard at the Base Pass Office to the Naval Exchange Complex (NEX) located just north of the site. Construction plans required only the addition of fill material; no cutting or grading of the landfill surface was performed. Seabee Road was completed and opened to the public on

August 6, 1993. Shortly thereafter, remedial investigation activities at the CD Landfill were begun. The road remains accessible to pedestrian and vehicular traffic.

In late September 1993, most of the existing debris mounds situated in the northern central portion of the landfill were leveled and spread around the site to reduce the amount of standing water which would accumulate after rain events. A small area of debris remains in the northern central part of the site.

At present, the majority of the landfilled area has been revegetated due in part to roadway construction restoration activities. Seabee Road recently has been landscaped with shrubbery and a fence has been installed on either side to eliminate public access from the right-of-way to the landfill area. Two drainage ditches border the site to the north and south. These drainage ditches flow eastward into culverts beneath the NAS which convey surface water runoff to Willoughby Bay.

1.1.3 Previous Investigations

Prior to the RI, the following studies of the CD Landfill Site were conducted:

- Initial Assessment Study (IAS)
- Confirmation Study
- Expanded Site Investigation (ESI)
- Limited Soils Study

In April 1982, an IAS was conducted at the Sewell's Point Naval Complex, Norfolk Naval Base, Norfolk, Virginia. The IAS identified 18 sites of concern with regard to potential contamination. The CD Landfill (Site 6) was included as a potential area of concern.

The IAS report, completed in February 1983, documented the disposal of ash and spent blasting grit at the site, as previously described. Based on the IAS findings, quarterly sampling of surface water and sediment was recommended. Surface water and sediment were sampled quarterly and then semi-annually from 1983 to 1985.

In 1987 a Confirmation Study of the CD Landfill Site was conducted by the Navy. Analysis of cadmium in surface waters indicated only slight contamination. Concentrations in the sediment samples ranged from less than 1 to 115 µg/g (ppm). The sediment was classified as heavily-polluted based on a comparison to general guidelines for soil contamination. Two potential sources of cadmium in the sediment were identified: erosion from the landfill surface and/or chemical precipitation as the shallow groundwater flows through the site into the adjacent drainage areas.

Environmental Science and Engineering, Inc. (ESE) conducted an ESI at the CD Landfill Site from February 1990 to June 1991. Twelve subsurface soil samples (two samples per boring) were collected from six well borings (MW-01 to MW-06). Two rounds of sediment and surface water samples were collected from five locations along the drainage ditches, and two rounds of groundwater sampling were performed.

Sediment and soil samples were analyzed for lead, iron, cadmium, pH, total organic halogens (TOX) and moisture content. The surface water and groundwater samples were analyzed for cadmium, groundwater indicator parameters (TOX, total organic carbon [TOC], pH, and specific conductivity), and groundwater quality parameters including lead, iron, sodium, and hardness.

Concentrations of cadmium, iron, lead and TOX were found to be present in subsurface soils across the site. These constituents were also detected in sediment with the greatest concentrations gradually increasing eastward. Lead concentrations exceeded Virginia Water Control Board (VWCB) standards in four of the six groundwater monitoring wells, and iron concentrations exceeded standards in all groundwater samples for both sampling events. Cadmium and lead were not detected in surface water.

In 1992, Froehling and Robertson, Inc. (F&R) conducted a limited soils study of the northwestern portion of the landfill in the vicinity of the proposed Seabee Road. Ten soil borings were completed, and two soil samples collected from each boring for analyses of total lead and total cadmium. In addition, five composite soil samples were collected and analyzed for Toxicity Characteristic Leaching Procedure (TCLP)-lead and TCLP-cadmium.

Analytical results indicated total lead and cadmium concentrations in soils. No samples exceeded the Virginia Department of Waste Management (VDWM) action levels for TCLP-lead or TCLP-cadmium.

Previous investigation results preliminarily identified areas of contamination, as well as important geologic/hydrogeologic considerations within the CD Landfill. In part, these results guided LANTDIV in the preparation of the scope of work for the Remedial Investigation. The composite information generated from the previous investigations noted above has been incorporated into this study's interpretation, as appropriate.

1.2 Remedial Investigation Field Activities and Results

The primary objectives of the RI at the CD Landfill Site were to identify and evaluate the physical and chemical characteristics of the CD Landfill area. Field activities performed in and around the site were designed to adequately describe site topography, subsurface geology, hydrogeologic features, primary waste characteristics, and the nature and extent of constituent migration resulting from past disposal practices at the CD Landfill.

1.2.1 Field Activities

The CD Landfill RI field effort was comprised of three individual mobilizations: Round 1 performed during August to September, 1993; Round 2 performed during December, 1993; and Round 3 performed during July, 1994. During the RI field efforts, the following activities were conducted:

- *Round 1* - geophysical survey (magnetic and electromagnetic surveys, ground penetrating radar); ecological survey (site walkover, vegetation survey, bird observations, and observations of animal signs); surface water and sediment sampling (eight and 14 locations, respectively); installation of 15 soil borings and eight monitoring wells (six screened across the water table [Columbia Aquifer], one replacement well screened at the base of the Columbia Aquifer, and one screened in the upper portion of the deep [Yorktown] aquifer) with associated surface/subsurface soil and groundwater sampling, aquifer (slug) testing, and a land survey.

- Round 2 - expansion of the geophysical survey to include those areas not accessible during Round 1; groundwater sampling (verification round); surface soil sampling (three locations).

- Round 3 - installation of one soil boring and two shallow monitoring wells with associated surface/subsurface soil and groundwater sampling, and a land survey of the new boring/well locations.

RI activities were performed in accordance with Final Project Plans CD Landfill RI/FS (Baker, 1993) and Round 3 Project Plan Addendum (Baker, 1994).

The various media sampled at the CD Landfill were selectively analyzed for VOCs, SVOCs, pesticides/PCBs, and inorganic compounds including total and dissolved fractions, and selected radionuclides, chlorinated herbicides, and asbestos. Select samples/media were also analyzed for indicator parameters such as chloride, sulfate, total alkalinity, hardness, total suspended solids, total organic carbon, and total organic halogens. Analyses were performed under Naval Energy and Environmental Support Activity (NEESA) and Contract Laboratory Program (CLP) protocols. In addition, NEESA Level D quality assurance procedures were followed.

1.2.2 Results

Information from the previous investigations of the CD Landfill Site, in conjunction with the data generated during the Remedial Investigation, have been carefully evaluated/interpreted to fulfill the original goals of the RI: (1) characterization of the geologic/hydrogeologic conditions at the site as they relate to the potential for migration of contaminants; and, (2) characterization of the nature and extent of contamination and associated potential impacts on human health and the environment. RI findings with regard to these two goals are summarized in the following sections.

1.2.2.1 Geology/Hydrogeology

Two physical characteristics of the CD Landfill area must be clearly understood prior to summarizing analytical results. These include site lithology and hydrogeologic characteristics. Site lithology, in general, consists of four separate strata: 1) fill/landfill materials (from 0 to 14 feet depth, increasing in thickness from west to east); and/or 2) silts and sands of the Columbia Group ranging from 30 to 50 feet beneath the soil cover and fill materials; 3) a clay layer at the base of the Columbia Group (extent and thickness not defined in this study, thickness of one foot observed in boring MW-05C); and, 4) a silt/sand/shell hash unit (Yorktown Formation) encountered between 40 and 58 feet below ground surface (bgs). Figure 1-3 presents a generalized geologic cross-section for the CD Landfill.

The Columbia (water table) Aquifer and, to some extent, the underlying Yorktown Aquifer are the primary aquifer systems of concern at the CD Landfill site. The Columbia Aquifer in the vicinity of the site is generally not suitable for potable (drinking water) use because of high concentrations of iron, manganese, and total dissolved solids, as well as low pH (less than 6). The deeper Yorktown Aquifer is generally suitable for potable uses, except near tidal waters, which can cause the water to be brackish in quality.

The water table (shallow groundwater) is an unconfined aquifer with a water level ranging from approximately four to six feet bgs, within the fill material. The unit extends to about 25 to 30 feet to a confining clay unit (if present). Figures 1-4 and 1-5 present the water table elevation contours and generalized groundwater flow patterns for the shallow Columbia Aquifer system based on data collected in September and December 1993, respectively. Shallow groundwater within the fill tends to follow the historical (now subsurface) land contours. Groundwater movement across the site, in general, appears to be to the northeast, but tends toward the direction of flow in the drainage ditches bordering the northern and eastern portions of the site in the immediate vicinity of the ditches. The maximum estimated groundwater flow velocity for the central portion of the site was calculated to be 3.5 feet per year. The maximum estimated groundwater flow velocity for the northeastern/eastern portion of the site was calculated to be 17.5 feet per year. The difference in groundwater flow velocity is based on the inconsistency of groundwater gradients throughout the site.

Based on regional information, it is believed that deeper groundwater in the Yorktown Aquifer flows in a more northerly direction towards the Elizabeth River and Willoughby Bay. Because the primary concern of the RI was to characterize groundwater conditions in the Columbia Aquifer, site-specific data were not generated to confirm deep groundwater flow direction as only one well was installed into the Yorktown Aquifer. Based on information generated during the RI for the Camp Allen Landfill site, located approximately 4,500 feet to the southeast, the Yorktown Aquifer is separated from the water table aquifer by a semi-confining clay unit. This leaky condition is primarily due to the presence of a breach and/or ineffective (poorly developed) portions of the confining clay unit at the base of the Columbia Group. The breached or ineffective portions allow for the downward migration of constituents. Average groundwater flow velocities in the Yorktown Aquifer range from approximately 0.001 to 0.08 feet/day (Baker 1994b).

1.2.2.2 Analytical Results

Detected constituents in site media are detailed in the RI Report. For purposes of the FS, a series of summary tables were taken from the RI report to present the range of constituent concentrations (minimum to maximum) detected in site media and provide a comparison to published standards and criteria including water quality standards, United States Environmental Protection Agency (USEPA) Region III Contaminant of Potential Concern (COPC) screening values (residential and industrial), NOAA sediment screening values and drinking water standards. Summary tables for each medium (surface soil, subsurface soil, shallow sediment, deep sediment, surface water, and groundwater) are presented in Tables 1-1 through 1-6.

1.3 Nature and Extent of Contamination

Based on site history, previous investigations and RI findings, contamination from prior disposal practices at the CD Landfill has impacted subsurface soils, surface soils, sediment, surface water, and groundwater (water table and potentially the Yorktown Aquifer systems). In general, the primary COPCs are several inorganic constituents, and, to a lesser extent, specific volatile organic, semivolatile organic and pesticide/PCB constituents. A brief summary of the nature and extent of contamination follows. This summary focuses on the primary COPCs associated with each medium and is not intended to address all results in detail. Detailed findings and data evaluation are presented in Section 6.0 of the RI Report (Baker, 1995).

- Fill characterization: The fill materials encountered at CD Landfill consist of metal, plastic, glass, wood and concrete debris, blast furnace cinders, wiring and miscellaneous construction rubble with a primary soil matrix of silt or sand. Distinguishing soil cover from surficially deposited fill material was difficult as each consisted of silt and sand. Fill material was generally encountered at or near ground surface to depths of between 3.5 and 12.0 feet bgs and tends to increase in thickness from west to east, indicating a gradual topographic low existed in the eastern portion of the site prior to landfilling operations. In addition, shallow fill was encountered north of the northern drainage ditch possibly due to past rail yard activities.

- Source Characterization: Based on the available information/analytical data, the major disposal area for the CD Landfill appears to be the central and eastern portions of the site, extending southeastward into the NAS glide path. The geophysical investigation indicated metal disposal in the eastern portion of the landfill and isolated areas in the northern, northwestern and southwestern sections of the site. However, no "hot spots" (i.e., discrete areas of contaminated soil which are potential sources of groundwater/surface water contamination) were identified for possible remediation (i.e., evaluation of hot spot remedial alternatives in the FS). The COPCs associated with the disposal areas are primarily inorganic constituents.

- Surface soil: Analytical results indicate surficial soil to be nominally impacted by disposal activities. Analytical results for VOCs, SVOCs, pesticides, and PCBs are shown in Figure 1-6. Inorganics and organics were detected site-wide; however, the concentrations were low and, with the exception of several inorganics, generally do not exceed risk-based concentrations for human health. These exceptions include lead and arsenic, which were detected in the surface soil sample collected from boring location SB07 at concentrations of 1,040 mg/kg and 34.9 mg/kg, respectively.

- Subsurface soil: Analytical results indicate subsurface soils (i.e., fill soils located beneath the top vegetative layer in potential contact with buried debris) to be impacted by disposal activities. As anticipated, based on the site disposal history, inorganic contamination is widely distributed over the site, and at least to the water table. In general, concentrations do not exceed risk-based concentrations except at specific locations.

- Surface water: Results indicate various inorganic and pesticide constituent concentrations exceeding Federal Ambient Water Quality Criteria and Virginia Water Quality standards, referred to in the ecological risk assessment as surface water screening levels (SWSLs). Analytical results for VOCs, SVOCs, pesticides, and PCBs are shown in Figure 1-7. Analytical results for total and dissolved inorganics are shown in Figure 1-8.

- Sediment: Results indicate several areas of inorganic , SVOC, and pesticide/PCB (dieldrin, PCB-1260) constituents in shallow sediments at levels above Region III sediment screening values (SSLs) and NOAA SSLs. Results for the deep sediments indicate sporadic areas of inorganics (mercury and arsenic) and pesticides/PCBs (dieldrin and 4,4'-DDT), and one SVOC (1,2-dichlorobenzene) at levels exceeding SSLs. Analytical results for VOCs, SVOCs, pesticides, and PCBs are shown in Figure 1-9 for shallow sediments; while inorganic analytical results for shallow sediments are shown in Figure 1-10. Figure 1-11 locates the organics in the deep sediments, and Figure 1-12 shows the deep sediment inorganics.

- Shallow Groundwater (water table) Aquifer: Analytical results for VOCs, SVOCs, pesticides, and PCBs are shown in Figure 1-13 for shallow groundwater. Total (unfiltered) and dissolved (filtered) inorganic analytical results for shallow groundwater are shown in Figures 1-14 and 1-15, respectively. At some locations, inorganics were detected in shallow groundwater at levels exceeding Maximum Contaminant Levels (MCLs), Virginia Groundwater Quality Standards, and Virginia Drinking Water Standards. Water quality parameters were also observed at levels in excess of MCLs and Virginia Water Quality Standards. However, drinking water standards are not applicable to the water table aquifer since shallow groundwater in the vicinity of the site is not suitable as a drinking water supply. The City of Norfolk has issued an ordinance prohibiting the use of shallow groundwater as a potable water supply in the Norfolk area. Elevated metals concentrations in unfiltered samples from shallow monitoring wells may be the result of turbidity (i.e., suspended solids) in the wells rather than actual leaching of contaminants from the soils to groundwater. No clear trends or plumes associated with inorganics are evident. Radionuclides were also observed at levels in excess of MCLs and Virginia Water Quality Standards. However, the presence of radionuclides appears to be indicative of natural origin. Chlorobenzene was detected in one shallow well at a concentration significantly above the MCL. The chlorobenzene contamination appears to be of relatively limited extent in the extreme eastern portion of the site. The contamination does not appear to be impacting surface water leaving the site.

- Deep Groundwater (Yorktown) Aquifer: Two monitoring wells (MW-3B and MW-5C) at the site provide data concerning the quality of groundwater in the Yorktown Aquifer. Sampling results from these two wells indicate that the Yorktown Aquifer has been marginally impacted by the landfill. No organic contaminants were detected in these wells during two sampling rounds (Round 1 and Round 2). During Round 1, lead was detected in an unfiltered sample from well MW-5C at 16.9 μg/L, which slightly exceeds the MCL of 15 μg/L. However, the Round 2 lead concentration was only 1.4 μg/l, and no lead was detected in the filtered samples collected from wells MW-3B and MW-5C in both sampling rounds. Iron and manganese concentrations exceeded secondary MCLs, established for aesthetic purposes, in MW-3B and MW5B generally by a factor of 2. However, these constituents may not be site-related and may be a result of turbidity in the wells caused by well bailing during sampling.

1.4 <u>Summary of Site Risks to Human Health</u>

The public health risks and ecological risks associated with contaminated media at the site were evaluated in detail in the Section 7.0 of the RI report (Baker, 1995). An ecological evaluation was also performed (see Section 1.5). This baseline assessment evaluated the potential risks which might result under the following current use and potential future use scenarios:

- Current Military Personnel (Table 1-7)
- Current/Future Adult and Child Trespassers (Table 1-8)
- Future Civilian Workers using Shallow Groundwater for Nonpotable Use (Table 1-9)
- Future Civilian Workers using Deep Groundwater for Nonpotable Use (Table 1-10)
- Future Construction Workers (Table 1-11)
- Future On-site Residents using Shallow Groundwater for Potable Use (Table 1-12)
- Future On-site Residents using Deep Groundwater for Potable Use (Table 1-13)

Incremental cancer risks (ICRs) and the potential to experience non-carcinogenic adverse effects (i.e., central nervous system effects, kidney effects, etc.), as measured by a hazard index (HI), were evaluated in this assessment. Estimated incremental cancer risks were compared to the target risk range of 10^{-4} to 10^{-6}, which the USEPA considers to be safe and protective of public health (USEPA, 1989). The calculated HI was compared to a threshold value of one. Below this level, there is minimal potential to experience noncarcinogenic adverse health effects. In addition, potential ecological effects were evaluated qualitatively.

The results of the human health risk assessment for the various exposure scenarios are summarized in the following sections.

1.4.1 Current Military Personnel

The current military personnel risk scenario was evaluated for military personnel stationed at the Naval Base who may contact surface soil, surface water, and sediment at the site. The scenario was based on an exposure duration of 4 years, which is the typical assignment period for the military. As shown in Table 1-7, there are no unacceptable risks to current military personnel posed by any of the contaminated media (i.e., soils, surface water, and sediment) at the CD Landfill Site.

1.4.2 Current/Future Adult and Child Trespassers

For the current/future adult and child trespasser scenario, it was conservatively assumed that adults and older children (ages 7-15 years old), who live in the vicinity of the site, may trespass onto the site and become exposed to site surface soil, surface water, and sediment. This scenario is considered conservative since the trespasser access is restricted by a chain-link fence that encloses the CD Landfill area. As shown in Table 1-8, the only medium that poses a potential unacceptable risk (through dermal contact) to human health is the shallow sediment, for which the ICR of 1.2×10^{-4} slightly exceeds the 1×10^{-4} threshold. The polynuclear aromatic hydrocarbons (PAHs) detected in the shallow sediment, such as benzo(a)pyrene, are the greatest contributors to this risk.

1.4.3 Future Civilian Workers using Shallow Groundwater for Nonpotable Use

This exposure scenario was evaluated for potential future civilian workers using shallow groundwater for nonpotable uses such as lawn watering and vehicle washing. As shown in Table 1-9, shallow groundwater poses a potential unacceptable risk to human health through dermal contact, for which the ICR is 7.7×10^{-4} and HI is 2.9. PCBs (Aroclor 1260) detected in the shallow groundwater are the greatest contributors to the cancer risk, and chlorobenzene is the primary noncarcinogen responsible for the elevated HI value. It should be noted that Aroclor 1260 was only detected in one monitoring well at a concentration of 0.12 μg/L in sampling round two. As with the trespasser exposure scenario, shallow sediment poses a potential unacceptable risk to human health under the civilian worker scenario through dermal contact, for which the ICR is 4.9×10^{-4}. Again, the PAHs detected in the shallow sediment are the greatest contributors to this risk.

1.4.4 Future Civilian Workers using Deep Groundwater for Nonpotable Use

This exposure scenario was evaluated for potential future civilian workers using deep groundwater (i.e., Yorktown Aquifer) for nonpotable uses such as lawn watering and vehicle washing. As shown in Table 1-10, the only medium that poses a potential unacceptable risk (through dermal contact) to human health is the shallow sediment, for which the ICR is 4.9×10^{-4}. Again, the PAHs detected in the shallow sediment are the greatest contributors to this risk.

1.4.5 Future Construction Workers

This exposure scenario was evaluated for potential construction workers who may contact surface and subsurface soils during any future excavation and construction activities performed at the site. As shown in Table 1-11, there are no unacceptable risks to potential construction workers under this exposure scenario.

1.4.6 Future On-site Residents using Shallow Groundwater for Potable Use

This exposure scenario was evaluated based on the unlikely scenario that the landfill would be used as a residential area in the future and that shallow groundwater would be used as a potable water source. As shown in Table 1-12, subsurface soils would pose slightly unacceptable carcinogenic (i.e., ICR exceeding 1 x 10^{-4}) and noncarcinogenic risks (i.e., HI exceeding 1) to both adults and children, primarily through dermal contact. Manganese was the greatest contributor to the risks associated with dermal contact and ingestion.

Under a potable use scenario, shallow groundwater would also pose unacceptable carcinogenic and noncarcinogenic risks to both adults and children, through dermal contact and ingestion. Manganese was the greatest contributor to the risk associated with groundwater ingestion, and Aroclor 1260 was the greatest risk driver for dermal contact.

As with the other exposure scenarios, the PAHs detected in the shallow sediment posed an unacceptable risk to adult receptors.

1.4.7 Future On-site Residents using Deep Groundwater for Potable Use

This exposure scenario is identical to the previously described residential scenario (Section 1.4.6) with the exception that deep groundwater (Yorktown Aquifer) would be used as a potable water source rather than the shallow aquifer. As shown in Table 1-13, no unacceptable risks would be posed by using the deep groundwater as a potable drinking water source, based on available groundwater data.

As with the other exposure scenarios, the PAHs detected in the shallow sediment posed an unacceptable risk to adult receptors.

1.5 Summary of Site Risks to the Ecology

This section summarizes the potential risks to the ecology at the site based on the ecological risk assessment presented in Section 8.0 of the RI report (Baker, 1995). It addresses impacts to the ecological integrity at CD Landfill from the COPCs detected in the media, and determines which COPCs are impacting the site to the greatest degree.

1.5.1 Aquatic Risk Summary

The surface water Quotient Indices (QIs) for total dieldrin, 4,4'-DDD, and 13 of the inorganics exceeded "1". However, only five of the dissolved inorganics had QIs that exceeded "1", and the concentrations were several orders of magnitude less than the total concentrations for most of the contaminants. This is significant in that primarily, it is only the dissolved fraction of inorganics that is bioavailable to aquatic receptors.

Dieldrin and 4,4'-DDD may cause a moderate risk to aquatic receptors via toxicity. The source of the pesticides was most likely past spraying for the control of site vegetation.

Cobalt, copper, and nickel only slightly exceeded their respective SWSLs; therefore, there is a slight potential risk to aquatic receptors from these contaminants. The potential risks to aquatic life from iron are expected to be high. In addition, iron increases in concentration in the downstream samples, and may be site-related.

The shallow sediment Effects Range-Medium (ER-M) QIs for the inorganics and PCBs were less than "1" in most of the samples, indicating a low potential for adverse impacts to aquatic life. Several SVOCs had ER-M QIs greater than 10, with most of these high exceedences noted at Station SD13S. The relatively high SVOC concentrations appear limited to this one station, with little migration to the downstream stations. Therefore, although there is a potential adverse risk to aquatic receptors from SVOCs in the sediment at CD Landfill, the risks appear limited to one station and should not significantly impact the aquatic receptor population. In addition, the SVOCs that were detected in SD13 are commonly anthropogenic and may be related to discharges from the adjacent chemical landfill where 1,000 5-gallon cans of roofing tar are reportedly buried, not from CD Landfill.

A few pesticides had ER-M QIs greater than "1". These exceedences were limited to Stations SD05S and SD13S. Similar to the SVOCs, the pesticides did not appear to migrate downstream of these stations, and should not significantly impact the aquatic receptor population as a whole. The highest pesticide concentrations were detected in the surface water samples collected downstream of Stations SD05S and SD13S. However, it is unknown if the pesticides in the water samples were due to the pesticides in the upstream sediments, since the pesticides in the sediments do not appear to be migrating downstream.

A few contaminants had QIs greater than unity in the deep sediments (2-2.5 feet). However, most of the aquatic receptors in the drainage ditch at CD Landfill are not expected to inhabit the deep sediments, and therefore should not be exposed to these contaminants.

Some of the contaminants detected in the surface water have a high potential for bioaccumulating in biota (i.e., pesticides, PCBs, and some inorganics). Therefore, there is the potential for some aquatic and terrestrial receptors to become exposed to contaminants that have bioaccumulated in the biota. This pathway was not quantitatively evaluated in the ecological risk assessment.

1.5.2 Terrestrial Risk Summary

Several of the inorganics, and a few organics, were detected at concentrations in the surface soils above the surface soil screening levels (SSSLs). There are some small areas of underbrush, narrow wooded strips, and wetlands located on the landfill. Therefore, potential adverse impacts to terrestrial flora and fauna may be possible. However, the terrestrial environment appeared to be unaffected by site contaminants based on visual observations. Gross effects of contamination (i.e., death or illness of wildlife, vegetative stress) were not observed. Although the terrestrial study was qualitative only, habitats appeared to be diverse and included species to be expected, particularly in an urban environment.

1.5.3 Threatened and Endangered Species

No federal or state endangered or threatened species are expected to be present at CD Landfill. However, the peregrine falcon has been sighted near Camp Allen which is located southeast of the CD Landfill Site. There is a low potential that the falcon will be feeding on fish in the drainage ditch, since the ditches are not large enough to support a significant fish population. Therefore, the risk of potential impacts to these threatened or endangered species from contaminants associated with CD Landfill is very small.

1.5.4 Wetlands

Opportunistic wetlands were observed at CD Landfill in the southern drainage ditch. Most of the COPCs in the surface water and sediment samples associated with this area were below the screening levels, or exceeded the levels by relatively small orders of magnitude. Therefore, potential impacts to wetlands from contaminants associated with CD Landfill are expected to be low.

1.6 Feasibility Study Report Organization

The FS Report is organized into seven sections. This introduction section (Section 1.0) presented a brief discussion of site background information, a summary of the RI, a discussion of the nature and extent of contamination, and an overview of the baseline risk assessment. The remedial action objectives that have been established for the site are outlined in Section 2.0. Identification and preliminary screening of general response actions, remedial action technologies, and process options are contained in Section 3.0. A detailed analysis based on a set of nine criteria including effectiveness, implementability, cost, acceptance, and overall protection of human health and the environment is included within Sections 4.0, 5.0, and 6.0 as follows. The detailed analyses of remedial alternatives and a comparative analysis of soil alternatives are presented in Section 4.0. The detailed analyses of remedial alternatives and a comparative analysis of groundwater (including institutional controls associated with surface water and sediment) alternatives are presented in Section 5.0; and the detailed analyses of remedial alternatives and a comparative analysis of sediment alternatives are presented in Section 6.0. References are listed in Section 7.0.

Two appendices are included with this FS: Appendix A presents the cleanup level calculations for the adult civilian worker as related to potential future use of the shallow aquifer for beneficial, non-potable use; and Appendix B details costing summaries and backup calculations for alternative cost estimates.

TABLE 1-1

SURFACE SOIL
ANALYTICAL RESULTS COMPARISON SUMMARY
CD LANDFILL SITE
NAVAL BASE, NORFOLK, VIRGINIA

Parameter	Site Background	USEPA Region III Industrial COPC Screening Values	USEPA Region III Residential COPC Screening Values	Concentration Range	No. of Detects Above Site Background	No. of Detects Above Industrial COPC Values	No. of Detects Above Residential COPC Values
INORGANICS (mg/kg)							
Aluminum	5550	300000	23000	1690J - 11100	11/20	0/20	0/20
Antimony	3.1UL	41	3.1	0.73J - 2.5J	2/20	0/20	0/20
Arsenic *	**1**	**31**	**2.3**	**2.6 - 34.9**	**20/20**	**1/20**	**20/20**
Barium	45.1	7200	550	16.8 - 106	8/20	0/20	0/20
Beryllium *	**0.21B**	**0.67**	**0.15**	**0.22B - 0.79B**	**13/20**	**1/20**	**13/20**
Cadmium	0.83U	51	3.9	0.33B - 2.3	7/20	0/20	0/20
Calcium	1040J	NE	NE	2600J - 155000J	20/20	NA	NA
Chromium	5.4	510	39	7.80 - 31.8	20/20	0/20	0/20
Cobalt	1.2U	NE	NE	1.3B - 6	18/20	NA	NA
Copper	2.4	3800	290	5.4 - 208	20/20	0/20	0/20
Iron	2760J	NE	NE	5010 - 18700	20/20	NA	NA
Lead	6.2	NE	NE	9.5J - 1040L	20/20	NA	NA
Magnesium	389	NE	NE	468 - 33600	20/20	NA	NA

TABLE 1-1 (Continued)

SURFACE SOIL
ANALYTICAL RESULTS COMPARISON SUMMARY
CD LANDFILL SITE
NAVAL BASE, NORFOLK, VIRGINIA

Parameter	Site Background	USEPA Region III Industrial COPC Screening Values	USEPA Region III Residential COPC Screening Values	Concentration Range	No. of Detects Above Site Background	No. of Detects Above Industrial COPC Values	No. of Detects Above Residential COPC Values
Manganese *	**29.6J**	**510**	**39**	**26.7J - 264J**	**19/20**	**0/20**	**18/20**
Mercury	0.05U	31	2.3	0.09 - 0.56	8/20	0/20	0/20
Nickel	2.4	2000	160	3.3 - 40.7	20/20	0/20	0/20
Potassium	238	NE	NE	348 - 1610	20/20	NA	NA
Selenium	0.21U	510	39	0.28 - 0.64	9/20	0/20	0/20
Sodium	154B	NE	NE	83.3B - 1730	20/20	NA	NA
Thallium	0.21U	NE	NE	0.23 - 0.54	13/20	NA	NA
Vanadium *	**10.9**	720	**55**	**12.2 - 78**	**20/20**	**0/20**	**2/20**
Zinc	8.9	31000	2300	24.8J - 982	20/20	0/20	0/20
Cyanide	0.52U	2000	160	0.51U - 0.98L	1/16	0/16	0/16
VOLATILE ORGANICS (ug/kg)							
Tetrachloroethene	10U	2.00e+08	1.60e+07	2J - 13U	1/6	0/6	0/6
SEMIVOLATILE ORGANICS (ug/kg)							
Phenanthrene	350U	NE	NE	52J - 92J	4/6	NA	NA
Fluoranthene	350U	4.10e+06	310000	34J - 420J	5/6	0/6	0/6

TABLE 1-1 (Continued)

SURFACE SOIL
ANALYTICAL RESULTS COMPARISON SUMMARY
CD LANDFILL SITE
NAVAL BASE, NORFOLK, VIRGINIA

Parameter	Site Background	USEPA Region III Industrial COPC Screening Values	USEPA Region III Residential COPC Screening Values	Concentration Range	No. of Detects Above Site Background	No. of Detects Above Industrial COPC Values	No. of Detects Above Residential COPC Values
Pyrene	350U	3.10e+06	230000	42J - 160J	5/6	0/6	0/6
Benzo(a)anthracene	350U	3900	880	46J - 94J	3/6	0/6	0/6
Chrysene	350U	390000	88000	31J - 150J	5/6	0/6	0/6
Bis(2-ethylhexyl)phthalate	23B	200000	46000	28B - 10000	3/6	0/6	0/6
Benzo(b)fluoranthene	18J	3900	880	28J - 210J	5/6	0/6	0/6
Benzo(k)fluoranthene	350U	39000	8800	28J - 81J	4/6	0/6	0/6
Benzo(a)pyrene *	**350U**	**390**	**88**	**19J - 93J**	**5/6**	0/6	**1/6**
Indeno(1,2,3-cd)pyrene	350U	3900	880	39J - 48J	2/6	0/6	0/6
Benzo(g,h,i)perylene	350U	NE	NE	23J - 61J	3/6	NA	NA
PESTICIDES/PCBs (ug/kg)							
Aldrin	0.67J	170	38	0.51J - 0.52J	0/6	0/6	0/6
Dieldrin *	**4.4L**	**180**	**40**	**2.4J - 51J**	**2/6**	0/6	**1/6**
4,4'-DDE	0.71J	8400	1900	1J - 3.1J	3/6	0/6	0/6
4,4'-DDD	3.5UL	12000	2700	0.7J - 4.2U	1/6	0/6	0/6
4,4'-DDT	1.7J	8400	1900	2.5J - 7.8L	3/6	0/6	0/6

TABLE 1-1 (Continued)

SURFACE SOIL
ANALYTICAL RESULTS COMPARISON SUMMARY
CD LANDFILL SITE
NAVAL BASE, NORFOLK, VIRGINIA

Parameter	Site Background	USEPA Region III Industrial COPC Screening Values	USEPA Region III Residential COPC Screening Values	Concentration Range	No. of Detects Above Site Background	No. of Detects Above Industrial COPC Values	No. of Detects Above Residential COPC Values
Endrin Aldehyde	3.5UL	NE	NE	0.29J - 4.2U	1/6	NA	NA
alpha-Chlordane	1.8UL	2200	470	0.3J - 0.5J	2/6	0/6	0/6
gamma-Chlordane	1.8UL	2200	470	0.097J - 2.2U	1/6	0/6	0/6
Aroclor-1260	35UL	370	83	12J - 27J	2/6	0/6	0/6

* Identifies Chemicals of Potential Concern (COPC) evaluated in the Baseline Risk Assessment.
NE - Not established
NA - Not applicable

TABLE 1-2

SUBSURFACE SOIL
ANALYTICAL RESULTS COMPARISON SUMMARY
CD LANDFILL SITE
NAVAL BASE, NORFOLK, VIRGINIA

Parameter	Site Background	USEPA Region III Industrial COPC Screening Values	USEPA Region III Residential COPC Screening Values	Concentration Range	No. of Detects Above Site Background	No. of Detects Above Industrial COPC Values	No. of Detects Above Residential COPC Values
INORGANICS (mg/kg)							
Aluminum	4470	300000	23000	1420 - 31600	25/38	0/38	2/38
Antimony *	**3.3UL**	**41**	**3.1**	**3.6L - 103L**	**6/38**	**2/38**	**6/38**
Arsenic *	**3.9**	**31**	**2.3**	**0.58J - 75.7**	**23/38**	**1/38**	**30/38**
Barium	33.8	7200	550	6.1B - 688J	17/38	0/38	1/38
Beryllium *	**0.22U**	**0.67**	**0.15**	**0.2B - 2.1B**	**19/38**	**5/38**	**19/38**
Cadmium *	**0.89U**	**51**	**3.9**	**0.61B - 50.4**	**9/38**	**0/38**	**3/38**
Calcium	908J	NE	NE	150J - 295000J	23/38	NA	NA
Chromium *	**10.1**	**510**	**39**	**3.5 - 1000**	**28/38**	**1/38**	**9/38**
Cobalt	1.3U	NE	NE	0.44B - 18.1	24/38	NA	NA
Copper *	**3.4**	**3800**	**290**	**0.92 - 3090**	**27/38**	**0/38**	**4/38**
Iron	6070J	NE	NE	2000J - 140000	25/38	NA	NA
Lead	5	NE	NE	1.9J - 3220J	23/38	NA	NA
Magnesium	354	NE	NE	230 - 8050	32/38	NA	NA
Manganese *	**10.3J**	**510**	**39**	**7.2J - 1900**	**34/38**	**7/38**	**18/38**

TABLE 1-2 (Continued)

SUBSURFACE SOIL
ANALYTICAL RESULTS COMPARISON SUMMARY
CD LANDFILL SITE
NAVAL BASE, NORFOLK, VIRGINIA

Parameter	Site Background	USEPA Region III Industrial COPC Screening Values	USEPA Region III Residential COPC Screening Values	Concentration Range	No. of Detects Above Site Background	No. of Detects Above Industrial COPC Values	No. of Detects Above Residential COPC Values
Mercury	0.05U	31	2.3	0.09 - 0.84	10/38	0/38	0/38
Nickel *	**1.6**	**2000**	**160**	**0.75J - 521**	**31/38**	**0/38**	**2/38**
Potassium	398	NE	NE	204 - 4290J	32/38	NA	NA
Selenium	NA	510	39	0.49B - 0.92B	NA	0/38	0/38
Silver	0.89U	510	39	1.1B - 182	6/38	0/38	1/38
Sodium	185B	NE	NE	33.8B - 4340	32/38	NA	NA
Thallium	0.29	NE	NE	0.24 - 0.94	15/38	NA	NA
Vanadium	14.1	720	55	5 - 349J	30/38	0/38	3/38
Zinc *	**6.3B**	**31000**	**2300**	**2.7B - 6220J**	**36/38**	**0/38**	**4/38**
Cyanide	0.65	2000	160	1.1 - 1.4	2/27	0/27	0/27
VOLATILE ORGANICS (ug/kg)							
Acetone	3B	1.00e+07	7.80e+05	3B - 34B	6/14	0/14	0/14
Carbon Disulfide	11U	1.00e+07	1.70e+05	9J - 12U	1/14	0/14	0/14
2-Butanone	11U	6.10e+07	4.70e+06	2J - 6J	5/14	0/14	0/14
Xylenes (total)	9J	5.50e+04	1.20e+04	8J - 12U	0/14	0/14	0/14

TABLE 1-2 (Continued)

SUBSURFACE SOIL
ANALYTICAL RESULTS COMPARISON SUMMARY
CD LANDFILL SITE
NAVAL BASE, NORFOLK, VIRGINIA

Parameter	Site Background	USEPA Region III Industrial COPC Screening Values	USEPA Region III Residential COPC Screening Values	Concentration Range	No. of Detects Above Site Background	No. of Detects Above Industrial COPC Values	No. of Detects Above Residential COPC Values
SEMIVOLATILE ORGANICS (ug/kg)							
Phenol	350U	6.10e+07	4.70e+06	18J - 34J	2/14	0/14	0/14
2-Methylphenol	NA	5.10e+06	3.90e+05	40J - 400U	1/14	0/14	0/14
Naphthalene	380U	4.10e+06	3.10e+05	42J - 310J	4/14	0/14	0/14
2-Methylnaphthalene	380U	NE	NE	32J - 170J	2/14	NA	NA
Acenaphthene	380U	6.10e+06	4.70e+05	40J - 100J	3/14	0/14	0/14
Dibenzofuran	NA	NE	NE	49J - 400U	1/14	NA	NA
Fluorene	NA	4.10e+06	3.10e+05	40J - 62J	3/14	0/14	0/14
Phenanthrene	380U	NE	NE	30J - 740	7/14	NA	NA
Anthracene	NA	3.10e+07	2.30e+06	42J - 120J	4/14	0/14	0/14
Carbazole	NA	1.40e+04	3.20e+04	54J - 400U	1/14	0/14	0/14
Di-n-butyl phthalate	310B	NE	NE	51B - 380B	1/14	NA	NA
Fluoranthene	380U	4.10e+06	3.10e+05	36J - 660	5/14	0/14	0/14
Pyrene	380U	3.10e+06	2.30e+05	36J - 570	6/14	0/14	0/14
Benzo(a)anthracene	NA	3900	880	54J - 200J	3/14	0/14	0/14

TABLE 1-2 (Continued)

SUBSURFACE SOIL
ANALYTICAL RESULTS COMPARISON SUMMARY
CD LANDFILL SITE
NAVAL BASE, NORFOLK, VIRGINIA

Parameter	Site Background	USEPA Region III Industrial COPC Screening Values	USEPA Region III Residential COPC Screening Values	Concentration Range	No. of Detects Above Site Background	No. of Detects Above Industrial COPC Values	No. of Detects Above Residential COPC Values
Chrysene	380U	390000	88000	48J - 240J	5/14	0/14	0/14
Bis(2-ethylhexyl)phthalate	470	200000	46000	46J - 470	0/14	0/14	0/14
Benzo(b)fluoranthene	380U	3900	880	30J - 220J	6/14	0/14	0/14
Benzo(k)fluoranthene	380U	39000	8800	20J - 140J	4/14	0/14	0/14
Benzo(a)pyrene	380U	390	88	35J - 180J	5/14	0/14	2/14
Indeno(1,2,3-cd)pyrene	380U	3900	880	23J - 130J	4/14	0/14	0/14
Dibenz(a,h)anthracene	NA	390	88	62J - 400U	1/14	0/14	0/14
Benzo(g,h,i)perylene	380U	NE	NE	20J - 140J	4/14	NA	NA
PESTICIDES/PCBs (ug/kg)							
Heptachlor	1.9U	640	140	0.5L - 0.99J	2/14	0/14	0/14
Aldrin	0.18J	170	38	0.12J - 3.3J	1/14	0/14	0/14
Dieldrin	1.5J	180	40	1.2J - 6.5J	5/14	0/14	0/14
4,4'-DDE	3.8U	8400	1900	0.46J - 35J	4/14	0/14	0/14
Endrin	NA	31000	2300	3.8UJ - 4.8J	1/14	0/14	0/14
4,4'-DDD	3.8U	12000	2700	1.5J - 21J	6/14	0/14	0/14

TABLE 1-2 (Continued)

SUBSURFACE SOIL
ANALYTICAL RESULTS COMPARISON SUMMARY
CD LANDFILL SITE
NAVAL BASE, NORFOLK, VIRGINIA

Parameter	Site Background	USEPA Region III Industrial COPC Screening Values	USEPA Region III Residential COPC Screening Values	Concentration Range	No. of Detects Above Site Background	No. of Detects Above Industrial COPC Values	No. of Detects Above Residential COPC Values
4,4'-DDT	0.53J	8400	1900	1.3J - 10J	3/14	0/14	0/14
Methoxychlor	NA	5.10e+05	39000	18U - 39J	3/14	0/14	0/14
Endrin Ketone	NA	NE	NE	3.8UJ - 7.8J	1/14	NA	NA
alpha-Chlordane	0.83J	2200	470	1.2J - 7J	4/14	0/14	0/14
gamma-Chlrodane	0.55J	2200	470	0.48J - 11L	5/14	0/14	0/14
Aroclor-1242	38U	370	83	23J - 41UJ	1/14	0/14	0/14
Aroclor-1260	38U	370	83	12J - 32J	3/14	0/14	0/14

* Identifies Chemicals of Potential Concern (COPC) evaluated in the Baseline Risk Assessment.
NE - Not established
NA - Not applicable

TABLE 1-3

SURFACE WATER
ANALYTICAL RESULTS COMPARISON SUMMARY
CD LANDFILL SITE
NAVAL BASE, NORFOLK, VIRGINIA

Parameter	Federal Water Quality Criteria	Virginia Water Quality Standards	USEPA Region III Tap Water COPC Screening Values	Site Background	Concentration Range	No. of Detects Above Federal Water Quality Criteria	No. of Detects Above Virginia Water Quality Standards	No. of Detects Above COPC Values	No. of Detects Above Background
INORGANICS (ug/L)									
Aluminum	NE	NE	11000	1970	296 J - 176000 J	NA	NA	2/8	4/8
Antimony *	**146**	**NE**	**1.5**	**12 U**	**12 U - 22.5**	**0/8**	**NA**	**1/8**	**1/8**
Arsenic *	**0.0022**	**50**	**1.1**	**2.7**	**2.7 - 40.1**	**7/8**	**0/8**	**7/8**	**6/8**
Barium *	**1000**	**2000**	**260**	**21.7**	**21.7 - 1420**	**1/8**	**0/8**	**2/8**	**7/8**
Calcium	NE	NE	NE	17200	17200 - 198000	NA	NA	NA	7/8
Chromium *	**50**	**170**	**18**	**5 U**	**5 U - 299**	**2/8**	**2/8**	**2/8**	**4/8**
Cobalt	NE	NE	NE	4 U	4 U - 128	NA	NA	NA	3/8
Copper *	**1000**	**1300**	**140**	**7.3 B**	**3.7 - 425**	**0/8**	**0/8**	**2/8**	**5/8**
Iron	300	300	NE	1790	1790 - 1470000 K	8/8	8/8	NA	7/8
Lead	50	15	NE	5.6	1 UL - 712	2/8	3/8	NA	6/8
Magnesium	NE	NE	NE	1330	1330 - 332000	NA	NA	NA	7/8
Manganese *	**50**	**50**	**18**	**21.4**	**21.4 - 6760**	**7/8**	**7/8**	**8/8**	**7/8**
Mercury	0.144	0.144	1.1	0.2U	0.1 U - 0.74	2/8	2/8	0/8	2/8
Nickel *	**13.4**	**607**	**73**	**6.5 B**	**6.5 B - 253**	**2/8**	**0/8**	**2/8**	**5/8**

TABLE 1-3 (Continued)

SURFACE WATER
ANALYTICAL RESULTS COMPARISON SUMMARY
CD LANDFILL SITE
NAVAL BASE, NORFOLK, VIRGINIA

Parameter	Federal Water Quality Criteria	Virginia Water Quality Standards	USEPA Region III Tap Water COPC Screening Values	*Site* Background	*Concentration* Range	No. of Detects Above Federal Water Quality Criteria	No. of Detects Above Virginia Water Quality Standards	No. of Detects Above COPC Values	No. of Detects Above Background
Potassium	NE	NE	NE	2380	2380 - 134000 J	NA	NA	NA	7/8
Silver	50	NE	18	3 U	3 U - 7.2	0/8	NA	0/8	3/8
Sodium	NE	NE	NE	2820	2820 - 3145000	NA	NA	NA	7/8
Thallium *	**13**	**NE**	**NE**	**1 U**	**1 U - 5 L**	**0/8**	**NA**	**NA**	**3/8**
Vanadium *	**NE**	**NE**	**26**	**13.5 B**	**13.5 B - 926**	**NA**	**NA**	**4/8**	**5/8**
Zinc *	**NE**	**5000**	**1100**	**87.7**	**31.4 B - 2640**	**NA**	**0/8**	**2/8**	**4/8**
Cyanide	200	700	NE	5 U	5 B - 25.1	0/8	0/8	NA	2/8
SEMIVOLATILE ORGANICS (ug/L)									
1,4-Dichlorobenzene *	**NE**	**400**	**0.44**	**10 U**	**0.7 J - 10 U**	**NA**	**0/8**	**2/8**	**2/8**
1,2-Dichlorobenzene	NE	2700	37	10 U	2 J - 10 U	NA	0/8	0/8	2/8
4-Methylphenol	NE	NE	NE	10 U	0.8 J - 10 U	NA	NA	NA	1/8
PESTICIDES/PCBs (ug/L)									
Dieldrin *	**0.000071**	**0.001**	**NE**	**0.1 UL**	**0.013 J - 0.1 U**	**4/8**	**4/8**	**NA**	**4/8**
4,4'-DDD	NE	NE	NE	0.1 UL	0.01 J - 0.1 U	NA	NA	NA	3/8

* Identifies Chemicals of Potential Concern (COPC) evaluated in the Baseline Risk Assessment.
NE - Not established
NA - Not applicable

TABLE 1-4

SHALLOW SEDIMENT
ANALYTICAL RESULTS COMPARISON SUMMARY
CD LANDFILL SITE
NAVAL BASE, NORFOLK, VIRGINIA

Parameter	USEPA Region III Industrial COPC Screening Values	USEPA Region III Residential COPC Screening Values	Sediment Screening Values ER-L	Sediment Screening Values ER-M	Site Background	Concentration Range	No. of Detects Above Industrial COPC Values	No. of Detects Above Residential COPC Values	No. of Detects Above ER-L Values	No. of Detects Above ER-M Values	No. of Detects Above Site Background
INORGANICS (mg/kg)											
Aluminum	NE	NE	2	25	3760	1,130J-15,500J	NA	NA	12/12	12/12	11/12
Arsenic *	**1.6**	**0.37**	**8**	**70**	**2.2**	**2.9L-49.2L**	**1/12**	**12/12**	**10/12**	**0/12**	**12/12**
Barium	7200	550	NE	NE	19.4	11.2J-687J	0/12	1/12	NA	NA	11/12
Cadmium	51	3.9	1.2	9.6	0.97 U	1.8-2.4	0/12	0/12	5/12	0/12	5/12
Calcium	NE	NE	NE	NE	11800 J	1,030J-63,700J	NA	NA	NA	NA	3/12
Chromium *	**510**	**39**	**81**	**370**	**7.4**	**3.3-190**	**0/12**	**2/12**	**1/12**	**0/12**	**11/12**
Cobalt	6100	470	NE	NE	1.5	2.2-19.8	0/12	0/12	NA	NA	11/12
Copper *	**3800**	**290**	**34**	**270**	**5.1**	**4.2J-429J**	**0/12**	**2/12**	**5/12**	**2/12**	**11/12**
Iron	NE	NE	NE	NE	3990 J	5,090J-207,000J	NA	NA	NA	NA	12/12
Lead	NE	NE	46	223	13.7	8.4J-1,260J	NA	NA	7/12	2/12	11/12
Magnesium	NE	NE	NE	NE	886	507J-3,850J	NA	NA	NA	NA	8/12
Manganese *	**510**	**39**	**NE**	**NE**	**23.6 J**	**49.4J-588J**	**3/12**	**12/12**	**NA**	**NA**	**12/12**
Mercury	31	2.3	0.15	223	0.16	0.14-1	0/12	0/12	4/12	0/12	3/12
Nickel *	**2000**	**160**	**21**	**0.71**	**5**	**11.8-423**	**0/12**	**1/12**	**5/12**	**10/12**	**10/12**

TABLE 1-4 (Continued)

SHALLOW SEDIMENT
ANALYTICAL RESULTS COMPARISON SUMMARY
CD LANDFILL SITE
NAVAL BASE, NORFOLK, VIRGINIA

Parameter	USEPA Region III Industrial COPC Screening Values	USEPA Region III Residential COPC Screening Values	Sediment Screening Values ER-L	Sediment Screening Values ER-M	Site Background	Concentration Range	No. of Detects Above Industrial COPC Values	No. of Detects Above Residential COPC Values	No. of Detects Above ER-L Values	No. of Detects Above ER-M Values	No. of Detects Above Site Background
Potassium	NE	NE	NE	NE	260	157-1,960	NA	NA	NA	NA	11/12
Silver	510	39	1	3.7	0.97 U	2.4-4.4	0/12	0/12	2/12	1/12	2/12
Sodium	NE	NE	NE	NE	249 B	236-949	NA	NA	NA	NA	10/12
Vanadium *	**720**	**55**	**NE**	**NE**	**21.6**	**7.9J-114J**	**0/12**	**10/12**	**NA**	**NA**	**11/12**
Zinc	31000	2300	150	410	105	83.3J-750J	0/12	0/12	7/12	2/12	9/12
VOLATILE ORGANICS (ug/kg)											
Methylene chloride	3.8e+04	8.5e+04	NE	NE	12 U	17J-30	0/12	0/12	NA	NA	2/12
Acetone	1.0e+08	7.8e+05	NE	NE	12 U	32-270	0/12	0/12	NA	NA	4/12
1,2-Dichloroethene, Total	9.2e+05	7.0e+04	NE	NE	12 U	3J-9J	0/12	0/12	NA	NA	2/12
2-Butanone	NE	NE	NE	NE	12 U	3J-54	NA	NA	NA	NA	5/12
Trichloroethene	2.6e+05	5.8e+04	NE	NE	12 U	8J-20U	0/12	1/12	NA	NA	1/12
Chlorobenzene	2.0e+06	1.6e+04	NE	NE	12 U	11UJ-140	0/12	0/12	NA	NA	1/12
SEMIVOLATILE ORGANICS (ug/kg)											
Phenol	6.1e+07	4.7e+06	NE	NE	400 U	23J-70J	0/12	0/12	NA	NA	3/12
1,3-Dichlorobenzene	9.1e+06	7.0e+05	NE	NE	400 U	21J-11000UJ	0/12	0/12	NA	NA	1/12

TABLE 1-4 (Continued)

SHALLOW SEDIMENT
ANALYTICAL RESULTS COMPARISON SUMMARY
CD LANDFILL SITE
NAVAL BASE, NORFOLK, VIRGINIA

Parameter	USEPA Region III Industrial COPC Screening Values	USEPA Region III Residential COPC Screening Values	Sediment Screening Values ER-L	Sediment Screening Values ER-M	Site Background	Concentration Range	No. of Detects Above Industrial COPC Values	No. of Detects Above Residential COPC Values	No. of Detects Above ER-L Values	No. of Detects Above ER-M Values	No. of Detects Above Site Background
1,4-Dichlorobenzene	1.2e+05	2.7e+04	NE	NE	400 U	27J-180J	0/12	0/12	NA	NA	3/12
1,2-Dichlorobenzene	9.2e+06	7.0e+05	NE	NE	400 U	39J-380J	0/12	0/12	NA	NA	4/12
1,2,4-Trichlorobenzene	1.0e+06	7.8e+04	NE	NE	400 U	21J-27J	0/12	0/12	NA	NA	2/12
Naphthalene	4.1e+06	3.1e+05	160	2100	400 U	43J-1,300J	0/12	0/12	1/12	0/12	5/12
2-Methylnaphthalene	NE	NE	70	670	400 U	56J-1,800J	NA	NA	2/12	1/12	3/12
Acenaphthylene	NE	NE	NE	NE	400 U	28J-11000UJ	NA	NA	NA	NA	1/12
Acenaphthene	6.1e+06	4.7e+04	16	500	400 U	370U-11,000J	0/12	0/12	1/12	1/12	1/12
Dibenzofuran	NE	NE	NE	NE	400 U	35J-8,400J	NA	NA	NA	NA	3/12
Fluorene	4.1e+06	3.1e+05	19	540	400 U	25J-15,000J	0/12	0/12	2/12	1/12	2/12
Phenanthrene	NE	NE	240	1500	22 J	23J-100,000J	NA	NA	2/12	1/12	9/12
Anthracene	3.1e+07	2.3e+06	85	1100	400 U	32J-32,000J	0/12	0/12	1/12	1/12	3/12
Carbazole	1.4e+05	3.2e+04	NE	NE	400 U	31J-22,000J	0/12	0/12	NA	NA	3/12
Fluoranthene	4.1e+06	3.1e+05	600	5100	28 B	26J-130,000J	0/12	0/12	1/12	1/12	7/12
Pyrene	3.1e+06	2.3e+06	665	2600	30 J	27J-76,000J	0/12	0/12	1/12	1/12	8/12
Butyl benzyl phthalate	2.0e+07	1.6e+06	NE	NE	400 U	30J-11,000UJ	0/12	0/12	NA	NA	1/12

TABLE 1-4 (Continued)

SHALLOW SEDIMENT
ANALYTICAL RESULTS COMPARISON SUMMARY
CD LANDFILL SITE
NAVAL BASE, NORFOLK, VIRGINIA

Parameter	USEPA Region III Industrial COPC Screening Values	USEPA Region III Residential COPC Screening Values	Sediment Screening Values ER-L	Sediment Screening Values ER-M	Site Background	Concentration Range	No. of Detects Above Industrial COPC Values	No. of Detects Above Residential COPC Values	No. of Detects Above ER-L Values	No. of Detects Above ER-M Values	No. of Detects Above Site Background
Benzo(a)anthracene *	**3.9e+03**	8.8e-02	**261**	**1600**	**400 U**	**240J-52,000J**	**1/12**	**1/12**	**1/12**	**1/12**	**2/12**
Chrysene	3.9e+05	8.8e+04	384	2800	21 J	28J-48,000J	0/12	0/12	2/12	1/12	7/12
Benzo(b)fluoranthene *	**3.9e+03**	8.8e+02	**NE**	**NE**	**27 J**	**22J-54,000J**	**1 /12**	**1 /12**	**NA**	**NA**	**9/12**
Benzo(k)fluoranthene *	**3.9e+04**	8.8e+03	**NE**	**NE**	**400 U**	**25J-22,000J**	**1/12**	**1/12**	**NA**	**NA**	**5/12**
Benzo(a)pyrene *	**3.9e+02**	8.8e+01	**430**	**1600**	**400 U**	**43J-38,000J**	**3/12**	**3/12**	**1/12**	**1/12**	**5/12**
Indeno(1,2,3-cd)pyrene *	**3.9e+03**	8.8e+02	**NE**	**NE**	**400 U**	**31J-14,000J**	**1/12**	**1/12**	**NA**	**NA**	**5/12**
Dibenz(a,h)anthracene *	**3.9e+02**	8.8e+01	**63**	**260**	**400 U**	**18J-3,900J**	**1/12**	**1/12**	**1/12**	**1/12**	**3/12**
Benzo(g,h,i)perylene	NE	NE	NE	NE	400 U	33J-12,000J	NA	NA	NA	NA	5/12
PESTICIDES/PCBs (ug/kg)											
beta-BHC	NE	NE	NE	NE	2.1 UL	1.8 J-18U	NA	NA	NA	NA	1/12
Heptachlor epoxide	3.1e+02	7.0e+01	NE	NE	2.1 UL	0.98 J-12U	0/12	0/12	NA	NA	1/12
Dieldrin *	**1.8e+02**	**4.0e+01**	**0.02**	8	**2.9 J**	**1.4J-120**	**9 /12**	**9 /12**	**12/12**	**4/12**	**9/12**
4,4'-DDE	8.4e+03	1.9e+03	2	15	1 J	0.46J-180	0/12	0/12	6/12	1/12	8/12
4,4'-DDD	1.2e+04	2.7e+02	2	20	1.5 J	0.71J-33J	0 /12	0 /12	8/12	1/12	8/12
4,4'-DDT	8.4e+03	1.9e+03	1	7	2.1 UL	2.6J-110	0/12	012	4/12	2/12	4/12

TABLE 1-4 (Continued)

SHALLOW SEDIMENT
ANALYTICAL RESULTS COMPARISON SUMMARY
CD LANDFILL SITE
NAVAL BASE, NORFOLK, VIRGINIA

Parameter	USEPA Region III Industrial COPC Screening Values	USEPA Region III Residential COPC Screening Values	Sediment Screening Values ER-L	Sediment Screening Values ER-M	Site Background	Concentration Range	No. of Detects Above Industrial COPC Values	No. of Detects Above Residential COPC Values	No. of Detects Above ER-L Values	No. of Detects Above ER-M Values	No. of Detects Above Site Background
Endrin aldehyde	NE	NE	NE	NE	2.1 UL	2.7J-36U	NA	NA	NA	NA	1/12
alpha-Chlordane	2.2e+03	4.9e+02	NE	NE	2.1 UL	2J-11J	0/12	0/12	NA	NA	3/12
gamma-Chlordane	2.2e+03	4.9e+02	NE	NE	2.1 UL	2.8J-4.9J	0/12	0/12	NA	NA	2/12
PCB-1248 *	**3.7e+02**	**8.3e+01**	**NE**	**NE**	**2.1 UL**	**33J-94**	**0/12**	**1/12**	**NA**	**NA**	**2/12**
PCB-1254	3.7e+02	8.3e+01	NE	NE	2.1 UL	19J-52J	0/12	0/12	NA	NA	2/12
PCB-1260 *	**3.7e+02**	**8.3e+01**	**NE**	**NE**	**2.1 UL**	**9.3J-94J**	**1/12**	**1/12**	**NA**	**NA**	**9/12**

* Identifies Chemicals of Potential Concern (COPC) evaluated in the Baseline Risk Assessment.
NE - Not established
NA - Not applicable

TABLE 1-5

DEEP SEDIMENT
ANALYTICAL RESULTS COMPARISON SUMMARY
CD LANDFILL SITE
NAVAL BASE, NORFOLK, VIRGINIA

PARAMETER	USEPA Region III Industrial COPC Screening Values	USEPA Region III Residential COPC Screening Values	Sediment Screening Values ER-L	Sediment Screening Values ER-M	Site Background	Concentration Range	No. of Detects Above Industrial COPC Values	No. of Detects Above Residential COPC Values	No. of Detects Above ER-L Values	No. of Detects Above ER-M Values	No. of Detects Above Site Background
INORGANIC (mg/kg)											
Aluminum	NE	NE	2	25	3760	1,820J-19,400	NA	NA	8/8	8/8	5/8
Arsenic *	**1.6**	**0.37**	**8**	**70**	**2.2**	**1.1L-9.2L**	**6/8**	**8/8**	**1/8**	**0/8**	**6/8**
Barium	7200	550	NE	NE	19.4	7.4J-85.1	0/8	0/8	NA	NA	3/8
Beryllium *	**0.067**	**0.015**	**NE**	**NE**	**0.24 U**	**0.22U - 0.92**	**1/8**	**1/8**	**NA**	**NA**	**1/8**
Calcium	NE	NE	NE	NE	11800 J	242J-47,700J	NA	NA	NA	NA	2/8
Chromium	510	39	81	370	7.4	3.9-18.1	0/8	0/8	0/8	0/8	4/8
Cobalt	6100	470	NE	NE	1.5	1.4-4.7	0/8	0/8	NA	NA	5/8
Copper	3800	290	34	270	5.1	3J-13.8J	0/8	0/8	0/8	0/8	5/8
Iron	NE	NE	NE	NE	3990 J	1,990J-17,300J	NA	NA	NA	NA	6/8
Lead	NE	NE	46	223	13.7	3.7J-13.1J	NA	NA	0/8	0/8	0/8
Magnesium	NE	NE	NE	NE	886	174J-1,200	NA	NA	NA	NA	2/8
Manganese *	**510**	**39**	**NE**	**NE**	**23.6 J**	**14J-211J**	**0/8**	**0/8**	**NA**	**NA**	**4/8**
Mercury	31	2.3	0.15	223	0.16	0.07-0.94	0/8	0/8	1/8	0/8	1/8
Nickel	2000	160	21	0.71	5	11.9-12.6	0/8	0/8	0/8	2/8	2/8
Potassium	NE	NE	NE	NE	260	170-663	NA	NA	NA	NA	7/8
Sodium	NE	NE	NE	NE	249 B	112-584	NA	NA	NA	NA	2/8
Vanadium	720	55	NE	NE	21.6	4.9J-34.6J	0/8	0/8	NA	NA	3/8
Zinc	31000	2300	150	410	105	25.9-47.1	0/8	0/8	0/8	0/8	0/8

TABLE 1-5 (Continued)

DEEP SEDIMENT
ANALYTICAL RESULTS COMPARISON SUMMARY
CD LANDFILL SITE
NAVAL BASE, NORFOLK, VIRGINIA

PARAMETER	USEPA Region III Industrial COPC Screening Values	USEPA Region III Residential COPC Screening Values	Sediment Screening Values ER-L	Sediment Screening Values ER-M	Site Background	Concentration Range	No. of Detects Above Industrial COPC Values	No. of Detects Above Residential COPC Values	No. of Detects Above ER-L Values	No. of Detects Above ER-M Values	No. of Detects Above Site Background
VOLATILE ORGANICS (ug/kg)											
Methylene Chloride	3.8e+04	8.5e+04	NE	NE	12U	2J - 6J	0/8	0/8	NA	NA	2/8
1,2-Dichloroethene, Total	9.2e+05	7.0e+04	NE	NE	12U	6J - 12U	0/8	0/8	NA	NA	1/8
2-Butanone	NE	NE	NE	NE	12U	3J - 4J	NA	NA	NA	NA	4/8
Trichloroethene	2.6e+05	5.8e+04	NE	NE	12U	11U - 13	0/8	0/8	NA	NA	1/8
Xylenes, Total	1.8e+08	1.6e+07	NE	NE	12U	2J - 12U	0/8	0/8	NA	NA	1/8
SEMIVOLATILE ORGANICS (ug/kg)											
1,4-Dichlorobenzene	1.2e+05	2.7e+04	NE	NE	400U	23J - 410U	0/8	0/8	NA	NA	1/8
1,2-Dichlorobenzene	9.2e+06	7.0e+05	NE	NE	400U	150J - 410U	0/8	0/8	NA	NA	1/8
1,2,4-Trichlorobenzene	1.0e+06	7.8e+04	NE	NE	400U	22J - 410U	0/8	0/8	NA	NA	1/8
Naphthalene	4.1e+06	3.1e+05	160	2100	400U	32J - 400U	0/8	0/8	0/8	0/8	1/8
Phenanthrene	NE	NE	240	1500	22J	24J - 40J	NA	NA	0/8	0/8	2/8
Fluoranthene	4.1e+06	3.1e+05	600	5100	28B	22J - 44J	0/8	0/8	0/8	0/8	1/8
Pyrene	3.1e+06	2.3e+06	665	2600	30J	47J - 410U	0/8	0/8	0/8	0/8	1/8
Chrysene	3.9e+05	8.8e+04	384	2800	21J	32J - 410U	0/8	0/8	0/8	0/8	1/8
Benzo(b)fluoranthene	3.9e+03	8.8e-02	NE	NE	27J	22J - 36J	0/8	0/8	NA	NA	2/8

TABLE 1-5 (Continued)

DEEP SEDIMENT
ANALYTICAL RESULTS COMPARISON SUMMARY
CD LANDFILL SITE
NAVAL BASE, NORFOLK, VIRGINIA

PARAMETER	USEPA Region III Industrial COPC Screening Values	USEPA Region III Residential COPC Screening Values	Sediment Screening Values ER-L	Sediment Screening Values ER-M	Site Background	Concentration Range	No. of Detects Above Industrial COPC Values	No. of Detects Above Residential COPC Values	No. of Detects Above ER-L Values	No. of Detects Above ER-M Values	No. of Detects Above Site Background
PESTICIDES/PCBs (ug/kg)											
beta-BHC	NE	NE	NE	NE	2.1 UL	1J - 2.1U	NA	NA	NA	NA	1/8
Aldrin	1.7e+02	3.8e+01	NE	NE	2.1 UL	0.34J-1.8J	0/8	0/8	NA	NA	2/8
Endosulfan I	NE	NE	NE	NE	2.1 UL	0.19J - 2.1U	NA	NA	NA	NA	1/8
Dieldrin	1.8e+02	4.0e+01	0.02	8	2.9 J	3.3J-6.9	0/8	0/8	3/8	0/8	3/8
4,4'-DDE	8.4e+03	1.9e+03	2	15	1 J	0.43J-16	0/8	0/8	1/8	1/8	1/8
4,4'-DDD	1.2e+04	2.7e+02	2	20	1.5 J	1.4J - 4.1U	0/8	0/8	0/8	0/8	0/8
4,4'-DDT	8.4e+03	1.9e+03	1	7	1 J	0.18J-11	0/8	0/8	1/8	1/8	1/8
PCB-1260	3.7e+02	8.3e+01	NE	NE	40 UL	10J - 41U	0/8	0/8	NA	NA	1/8

* Identifies Chemicals of Potential Concern (COPC) evaluated in the Baseline Risk Assessment.
NE - Not established
NA - Not applicable

TABLE 1-6

GROUNDWATER
ANALYTICAL RESULTS COMPARISON SUMMARY
CD LANDFILL SITE
NAVAL BASE, NORFOLK, VIRGINIA

PARAMETER	Federal MCL/MCLG	Virginia Groundwater Standards	Virginia Drinking Water Standards	USEPA Region III Tap Water COPC Screening Values	Site Background	Concentration Range	No. of Detects Above MCL/MCLG	No. of Detects Above State Groundwater Standards	No. of Detects Above State Drinking Water Standards	No. of Detects Above COPC Values	No. of Detects Above Background
INORGANICS (ug/L)											
Aluminum	NE	NE	NE	11000	24100	83.6 - 208000	NA	NA	NA	15/29	10/29
Antimony *	**6**	**NE**	**NE**	**1.5**	**NE**	**1.3 - 33.6**	**15/21**	**NA**	**NA**	**14/21**	**NA**
Arsenic *	**50**	**50**	**50**	**1.1**	**9.1**	**2.6 - 65.6**	**2/29**	**2/29**	**2/29**	**25/29**	**18/29**
Barium *	**2000**	**1000**	**2000**	**260**	**80.2**	**16.8 - 1940**	**0/29**	**0/29**	**0/29**	**5/29**	**18/29**
Beryllium *	**4**	**NE**	**NE**	**0.016**	**14.3**	**0.8 - 14.7**	**4/29**	**NA**	**NA**	**7/29**	**1/29**
Cadmium *	**5**	**10**	**NE**	**1.8**	**19.1**	**4.7 - 21.8**	**8/29**	**4/29**	**0/29**	**8/29**	**2/29**
Calcium	NE	NE	NE	NE	64500	5560 - 335000	NA	NA	NA	0/29	18/29
Chromium	100	50	170	18	28.1	7.5 - 309	7/29	12/29	2/29	18/29	16/29
Cobalt	NE	NE	NE	NE	99.9	6 - 99.9	NA	NA	NA	0/29	0/29
Copper *	**1300**	**1000**	**1300**	**140**	**20.9**	**2.2 - 534**	**0/29**	**0/29**	**0/29**	**3/29**	**14/29**
Iron	NE	300	300	NE	47200	1240 - 177000	NA	29/29	29/29	0/29	12/29
Lead	15	50	15	NE	7.2	1.2 - 864	18/29	10/29	18/29	0/29	22/29
Magnesium	NE	NE	NE	NE	23900	659 - 77900	NA	NA	NA	0/29	20/29
Manganese *	**NE**	**50**	**50**	**18**	**1720**	**45.8 - 6560**	**NA**	**29/29**	**29/29**	**29/29**	**4/29**

TABLE 1-6 (Continued)

GROUNDWATER
ANALYTICAL RESULTS COMPARISON SUMMARY
CD LANDFILL SITE
NAVAL BASE, NORFOLK, VIRGINIA

PARAMETER	Federal MCL/MCLG	Virginia Groundwater Standards	Virginia Drinking Water Standards	USEPA Region III Tap Water COPC Screening Values	Site Background	Concentration Range	No. of Detects Above MCL/MCLG	No. of Detects Above State Groundwater Standards	No. of Detects Above State Drinking Water Standards	No. of Detects Above COPC Values	No. of Detects Above Background
Mercury	2	2	NE	1.1	0.2U	0.26 - 1.1	0/29	0/29	NA	1/29	6/29
Nickel *	**100**	**NE**	**NE**	**73**	**80.3**	**3.3 - 138**	**2/29**	**NA**	**NA**	**5/29**	**4/29**
Potassium	NE	NE	NE	NE	5510	439 - 56300	NA	NA	NA	0/29	18/29
Selenium	50	10	NE	18	NE	1.8 - 5.6	0/16	0/16	NA	0/16	NA
Silver	NE	50	NE	18	4U	0.69 - 8.6	NA	0/29	NA	0/29	3/29
Sodium	NE	270000	NE	NE	25100	121 - 539000	NA	2/29	NA	0/29	25/29
Thallium	2	NE	NE	NE	1UL	0.32 - 1.1	0/29	NA	NA	0/29	3/29
Vanadium *	**NE**	**NE**	**NE**	**26**	**39.8**	**5.9 - 504**	**NA**	**NA**	**NA**	**17/29**	**15/29**
Zinc *	**NE**	**50**	**5000**	**1100**	**871**	**8 - 3780**	**NA**	**18/29**	**0/29**	**4/29**	**6/29**
VOLATILE ORGANIC (ug/L)											
Methylene Chloride	5	NE	NE	4.1	10U	2-170UJ	0/6	NA	NA	0/6	1/6
Chloroform	100	NE	NE	0.15	10U	3 - 5	0/6	NA	NA	2/6	2/6
Chlorobenzene *	**100**	**NE**	**NE**	**3.9**	**10U**	**3 - 2000**	**2/6**	**NA**	**NA**	**3/6**	**4/6**
SEMIVOLATILE ORGANICS (ug/L)											
Phenol	NE	NE	NE	NE	10U	3 - 5	NA	NA	NA	0/26	3/26

TABLE 1-6 (Continued)

GROUNDWATER
ANALYTICAL RESULTS COMPARISON SUMMARY
CD LANDFILL SITE
NAVAL BASE, NORFOLK, VIRGINIA

PARAMETER	Federal MCL/MCLG	Virginia Groundwater Standards	Virginia Drinking Water Standards	USEPA Region III Tap Water COPC Screening Values	Site Background	Concentration Range	No. of Detects Above MCL/MCLG	No. of Detects Above State Groundwater Standards	No. of Detects Above State Drinking Water Standards	No. of Detects Above COPC Values	No. of Detects Above Background
2-Chlorophenol	NE	NE	NE	NE	10U	8 - 16	NA	NA	NA	0/26	2/26
1,3-Dichlorobenzene	600	NE	NE	54	10U	5J -10U	0/26	NA	NA	0/26	2/26
1,4-Dichlorobenzene *	**75**	**NE**	**NE**	**0.44**	**10U**	**12 - 13**	**0/26**	**NA**	**NA**	**2/26**	**2/26**
1,2-Dichlorobenzene	600	NE	NE	37	10U	10 - 11	0/26	NA	NA	0/26	2/26
4-Methylphenol	NE	NE	NE	NE	10U	0.7 - 2	NA	NA	NA	0/26	4/26
2,4-Dimethylphenol	NE	NE	NE	NE	10U	0.50J - 10U	NA	NA	NA	0/26	1/26
Naphthalene	NE	NE	NE	NE	10U	1 - 3	NA	NA	NA	0/26	5/26
2-Methylnaphthalene	NE	NE	NE	NE	10U	0.7 - 1	NA	NA	NA	0/26	5/26
Acenaphthene	NE	NE	NE	NE	10U	1 - 6	NA	NA	NA	0/24	4/24
Dibenzofuran	NE	NE	NE	NE	10U	1 - 2	NA	NA	NA	0/26	2/26
Diethylphthalate	NE	NE	NE	NE	10U	0.5 - 7	NA	NA	NA	0/28	8/28
Fluorene	NE	NE	NE	NE	10U	0.6 - 1	NA	NA	NA	0/26	4/26
N-Nitrosodiphenylamine	NE	NE	NE	NE	10U	4J - 10U	NA	NA	NA	0/26	1/26
Phenanthrene	NE	NE	NE	NE	10U	0.5 - 2	NA	NA	NA	0/26	6/26
Anthracene	NE	NE	NE	NE	10U	0.6 - 1	NA	NA	NA	0/25	2/25

TABLE 1-6 (Continued)

GROUNDWATER
ANALYTICAL RESULTS COMPARISON SUMMARY
CD LANDFILL SITE
NAVAL BASE, NORFOLK, VIRGINIA

PARAMETER	Federal MCL/MCLG	Virginia Groundwater Standards	Virginia Drinking Water Standards	USEPA Region III Tap Water COPC Screening Values	Site Background	Concentration Range	No. of Detects Above MCL/MCLG	No. of Detects Above State Groundwater Standards	No. of Detects Above State Drinking Water Standards	No. of Detects Above COPC Values	No. of Detects Above Background
Carbazole	NE	NE	NE	NE	10U	0.5 - 1	NA	NA	NA	0/26	4/26
Di-n-butylphthalate	NE	NE	NE	NE	10U	0.5 - 2	NA	NA	NA	0/25	7/25
Fluoranthene	NE	NE	NE	NE	10U	0.5 - 2	NA	NA	NA	0/26	5/26
Pyrene	NE	NE	NE	NE	10U	0.5 - 2	NA	NA	NA	0/26	3/26
Butylbenzylphthalate	NE	NE	NE	730	10U	0.55J - 10U	NA	NA	NA	0/25	1/25
Bis(2-ethylhexyl)phthalate	6	NE	NE	4.8	1	0.5 - 9	1/26	NA	NA	1/26	6/26
PESTICIDES/PCBs (ug/L)											
Beta-BHC	NE	NE	NE	NE	0.05UJ	0.034J - 0.05UL	NA	NA	NA	0/24	1/24
Heptachlor Epoxide	0.2	NE	NE	0.0012	0.05UJ	0.03J - 0.05U	0/26	NA	NA	2/24	1/24
Dieldrin *	**NE**	**NE**	**NE**	**NE**	**0.1UJ**	**0.006 - 0.04**	**NA**	**NA**	**NA**	**0/24**	**6/24**
4,4'-DDD	NE	NE	NE	NE	0.1UJ	0.015 - 0.02	NA	NA	NA	0/24	3/24
4,4'-DDT	NE	NE	NE	NE	0.1UJ	0.016 - 0.02	NA	NA	NA	0/24	2/24
Endrin Aldehyde	NE	NE	NE	NE	0.1UJ	0.017	NA	NA	NA	0/24	1/24
gamma-Chlordane	NE	NE	NE	NE	0.05UJ	0.005	NA	NA	NA	0/24	1/24
Aroclor-1260 *	**0.5**	**NE**	**NE**	**NE**	**1UJ**	**0.120**	**NA**	**NA**	**NA**	**0/24**	**1/24**

TABLE 1-6 (Continued)

GROUNDWATER
ANALYTICAL RESULTS COMPARISON SUMMARY
CD LANDFILL SITE
NAVAL BASE, NORFOLK, VIRGINIA

* Identifies Chemicals of Potential Concern (COPC) evaluated in the Baseline Risk Assessment.
NE - Not established
NA - Not applicable

TABLE 1-7

INCREMENTAL LIFETIME CANCER RISKS (ILCRs)
AND HAZARD INDICES (HIs)
FOR CURRENT MILITARY PERSONNEL
CD LANDFILL SITE
NAVAL BASE, NORFOLK, VIRGINIA

	Receptor	
	Adult Military Personnel	
Medium/Pathway	ILCR	HI
Surface Soil		
Ingestion	7.6×10^{-7}	3.4×10^{-2}
Dermal Contact	4.8×10^{-6}	7.3×10^{-2}
Inhalation(1)	8.2×10^{-10}	7.8×10^{-4}
Subtotal	5.6×10^{-6}	1.1×10^{-1}
Surface Water		
Ingestion	2.6×10^{-7}	2.0×10^{-2}
Dermal Contact	1.0×10^{-6}	1.0×10^{-2}
Subtotal	1.3×10^{-6}	3.0×10^{-2}
Shallow Sediments		
Ingestion	6.0×10^{-7}	5.4×10^{-3}
Dermal Contact	7.9×10^{-6}	2.1×10^{-2}
Subtotal	8.5×10^{-6}	2.6×10^{-2}
Deep Sediments		
Ingestion	1.7×10^{-8}	7.5×10^{-4}
Dermal Contact	4.1×10^{-8}	1.9×10^{-3}
Subtotal	5.8×10^{-8}	2.6×10^{-3}
TOTAL	1.5×10^{-5}	1.7×10^{-1}

Notes:

(1) Inhalation of fugitive dusts.

TABLE 1-8

INCREMENTAL LIFETIME CANCER RISKS (ILCRs) AND HAZARD INDICES (HIs) FOR CURRENT/FUTURE ADULT AND CHILD TRESPASSERS CD LANDFILL SITE NAVAL BASE, NORFOLK, VIRGINIA

Medium/Pathway	Receptors			
	Adults		Children (7-15 years)	
	ILCR	HI	ILCR	HI
Surface Soil				
Ingestion	9.2×10^{-7}	5.4×10^{-3}	5.2×10^{-7}	1.0×10^{-2}
Dermal Contact	5.8×10^{-6}	1.2×10^{-2}	2.4×10^{-6}	1.6×10^{-2}
Subtotal	6.7×10^{-6}	1.7×10^{-2}	2.9×10^{-6}	2.6×10^{-2}
Surface Water				
Ingestion	2.6×10^{-6}	3.4×10^{-2}	1.5×10^{-6}	6.3×10^{-2}
Dermal Contact	1.5×10^{-5}	2.0×10^{-2}	6.9×10^{-6}	3.0×10^{-2}
Subtotal	1.9×10^{-5}	6.0×10^{-2}	9.1×10^{-6}	1.1×10^{-1}
Shallow Sediment				
Ingestion	1.8×10^{-5}	2.2×10^{-2}	1.0×10^{-5}	4.1×10^{-2}
Dermal Contact	1.2×10^{-4}	4.2×10^{-2}	5.3×10^{-5}	6.2×10^{-2}
Subtotal	1.4×10^{-4}	6.4×10^{-2}	6.3×10^{-5}	1.0×10^{-1}
Deep Sediment				
Ingestion	5.2×10^{-7}	3.0×10^{-3}	3.0×10^{-7}	5.7×10^{-3}
Dermal Contact	6.2×10^{-7}	3.9×10^{-3}	2.8×10^{-7}	5.8×10^{-3}
Subtotal	1.1×10^{-6}	6.9×10^{-3}	5.8×10^{-7}	1.2×10^{-2}
TOTAL	1.7×10^{-4}	1.4×10^{-1}	7.5×10^{-5}	2.3×10^{-1}

TABLE 1-10

INCREMENTAL LIFETIME CANCER RISKS (ILCRs) AND HAZARD INDICES (HIs)
FOR FUTURE CIVILIAN WORKERS (GROUNDSKEEPERS)
DEEP AQUIFER (WELL LOCATION GW-05C) USED AS NON-POTABLE SOURCE
CD LANDFILL SITE
NAVAL BASE, NORFOLK, VIRGINIA

	Receptor	
	Civilian Worker	
Medium/Pathway	ILCR	HI
Surface Soil		
Ingestion	4.0×10^{-6}	2.8×10^{-2}
Dermal Contact	4.1×10^{-5}	1.0×10^{-1}
Inhalation[(1)]	1.0×10^{-8}	1.6×10^{-3}
Subtotal	4.5×10^{-5}	1.3×10^{-1}
Deep Groundwater		
Ingestion	--	5.5×10^{-4}
Dermal Contact	--	4.4×10^{-3}
Subtototal		5.0×10^{-3}
Surface Water		
Ingestion	1.1×10^{-5}	1.7×10^{-1}
Dermal Contact	6.4×10^{-5}	9.9×10^{-2}
Subtotal	8.0×10^{-5}	3.0×10^{-1}
Shallow Sediment		
Ingestion	3.8×10^{-5}	5.4×10^{-2}
Dermal Contact	4.9×10^{-4}	2.1×10^{-1}
Subtotal	5.3×10^{-4}	2.6×10^{-1}
Deep Sediment		
Ingestion	1.1×10^{-6}	7.5×10^{-3}
Dermal Contact	2.6×10^{-6}	1.9×10^{-2}
Subtotal	3.7×10^{-6}	2.6×10^{-2}
TOTAL	6.5×10^{-4}	6.9×10^{-1}

Notes:
(1) Inhalation of fugitive dusts.

TABLE 1-13

**INCREMENTAL LIFETIME CANCER RISKS (ILCRs) AND HAZARD INDICES (HIs)
FOR FUTURE ADULT AND YOUNG CHILD ON-SITE RESIDENTS
DEEP AQUIFER (WELL LOCATION GW-05C) USED AS POTABLE SOURCE
CD LANDFILL SITE
NAVAL BASE, NORFOLK, VIRGINIA**

Medium/Pathway	Receptors			
	Adults		Young Children (1-6 years)	
	ILCR	HI	ILCR	HI
Surface Soil				
Ingestion	1.3×10^{-5}	7.8×10^{-2}	2.5×10^{-5}	7.3×10^{-1}
Dermal Contact	8.5×10^{-5}	1.7×10^{-1}	4.8×10^{-5}	4.8×10^{-1}
Inhalation(1)	1.4×10^{-9}	1.8×10^{-4}	2.7×10^{-9}	1.7×10^{-3}
Subtotal	9.8×10^{-5}	2.5×10^{-1}	7.3×10^{-5}	$1.2 \times 10^{+0}$
Subsurface Soil				
Ingestion	1.6×10^{-5}	9.1×10^{-1}	3.0×10^{-5}	$8.5 \times 10^{+0}$
Dermal Contact	2.9×10^{-4}	$3.9 \times 10^{+0}$	1.6×10^{-4}	$1.1 \times 10^{+1}$
Inhalation(1)	3.3×10^{-8}	2.2×10^{-3}	6.2×10^{-8}	2.1×10^{-2}
Subtotal	3.1×10^{-4}	$4.8 \times 10^{+0}$	1.9×10^{-4}	$2.0 \times 10^{+1}$
Deep Groundwater(2)				
Ingestion	--	2.7×10^{-2}	--	6.3×10^{-2}
Dermal Contact	--	1.1×10^{-3}	--	2.0×10^{-3}
Inhalation(3)	--	--	--	--
Subtotal	--	2.8×10^{-2}	--	6.5×10^{-2}
Surface Water				
Ingestion	2.6×10^{-6}	3.4×10^{-2}	2.4×10^{-6}	1.6×10^{-1}
Dermal Contact	1.5×10^{-5}	2.0×10^{-2}	8.0×10^{-6}	5.3×10^{-2}
Subtotal	1.9×10^{-5}	6.0×10^{-2}	1.2×10^{-5}	2.4×10^{-1}
Shallow Sediment				
Ingestion	1.8×10^{-5}	2.2×10^{-2}	3.4×10^{-5}	2.0×10^{-1}
Dermal Contact	1.2×10^{-4}	4.2×10^{-2}	6.1×10^{-5}	1.1×10^{-1}
Subtotal	1.4×10^{-4}	6.4×10^{-2}	9.5×10^{-5}	3.1×10^{-1}
Deep Sediment				
Ingestion	5.2×10^{-7}	3.0×10^{-3}	9.8×10^{-7}	2.8×10^{-2}
Dermal Contact	6.2×10^{-7}	3.9×10^{-3}	3.2×10^{-7}	1.0×10^{-2}
Subtotal	1.1×10^{-6}	6.9×10^{-3}	1.2×10^{-6}	3.8×10^{-2}
TOTAL	5.7×10^{-4}	$5.2 \times 10^{+0}$	3.7×10^{-4}	$2.2 \times 10^{+1}$

Notes:

(1) *Inhalation of fugitive dusts.*

(2) Risk levels presented are associated with potential exposures to organic and dissolved inorganic COPCs.

(3) Inhalation of volatilized organic COPC concentrations in shower air as determined by the Foster and Chrostowski Shower Model. Shower Model.

-- No COPCs identified for evaluation.

SOURCE: U.S.G.S. TOPOGRAPHIC MAP
NORFOLK NORTH QUADRANGLE
1965 (PHOTOREVISED 1986)

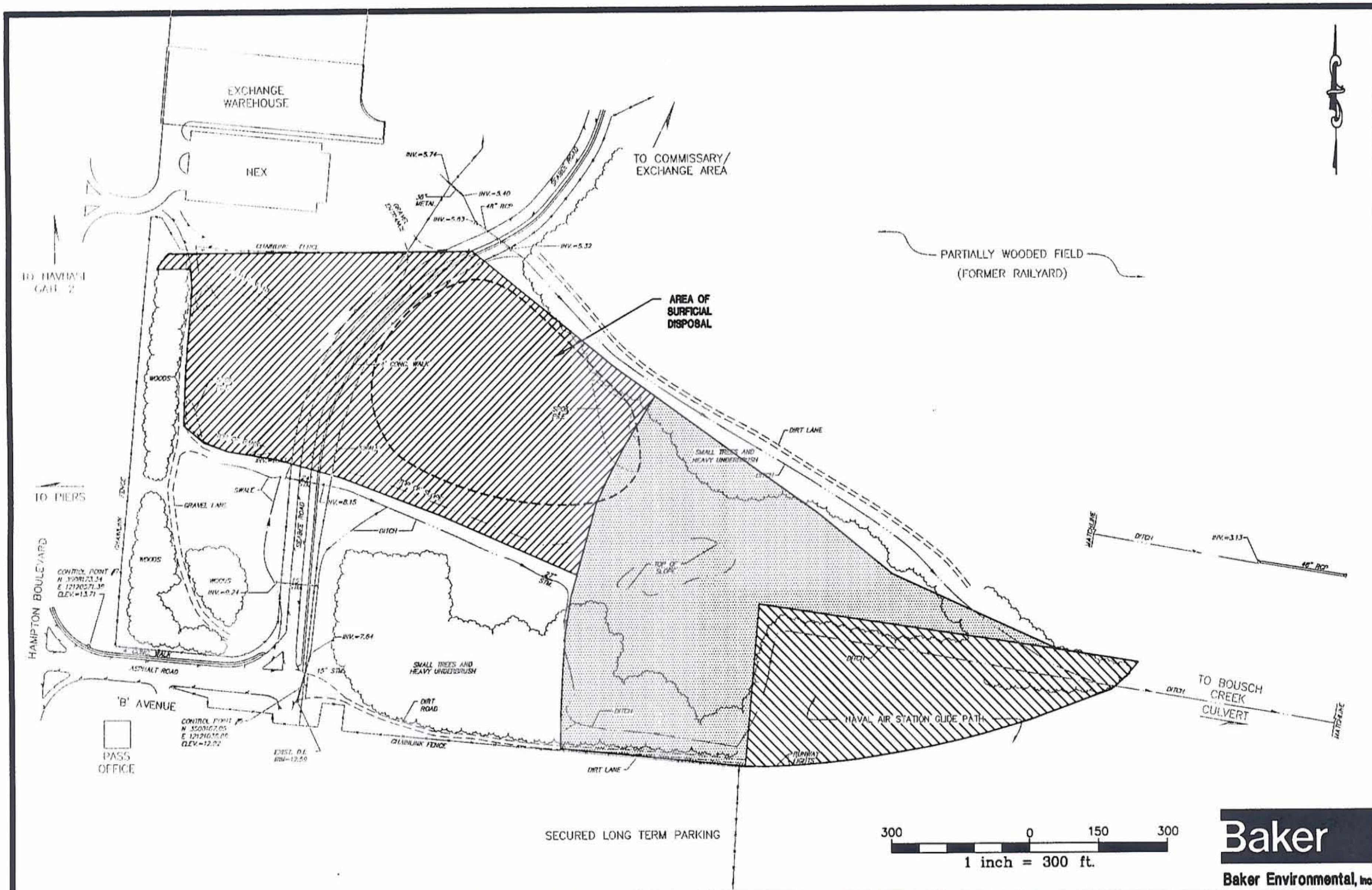
2000 0 1000 2000 4000

1 inch = 2000 ft.

Baker Environmental, Inc.

FIGURE 1-1
SITE LOCATION MAP
CD LANDFILL

NORFOLK NAVAL BASE
NORFOLK, VIRGINIA



Baker

Baker Environmental, Inc.

LEGEND

- FILL EXCAVATED DURING RUNWAY EXPANSION. 1979.
- APPROXIMATE LANDFILL, 1974–1979.
- LANDFILL, 1979–1987.

NOTE: SURFICIAL DISPOSAL AREA WAS LEVELED IN SEPTEMBER 1993.

SOURCE: HOGGARD/EURE, SEPT. 1993

FIGURE 1–2
AREA OF LANDFILL OPERATIONS
CD LANDFILL

NAVAL BASE NORFOLK
NORFOLK, VIRGINIA

138630RI

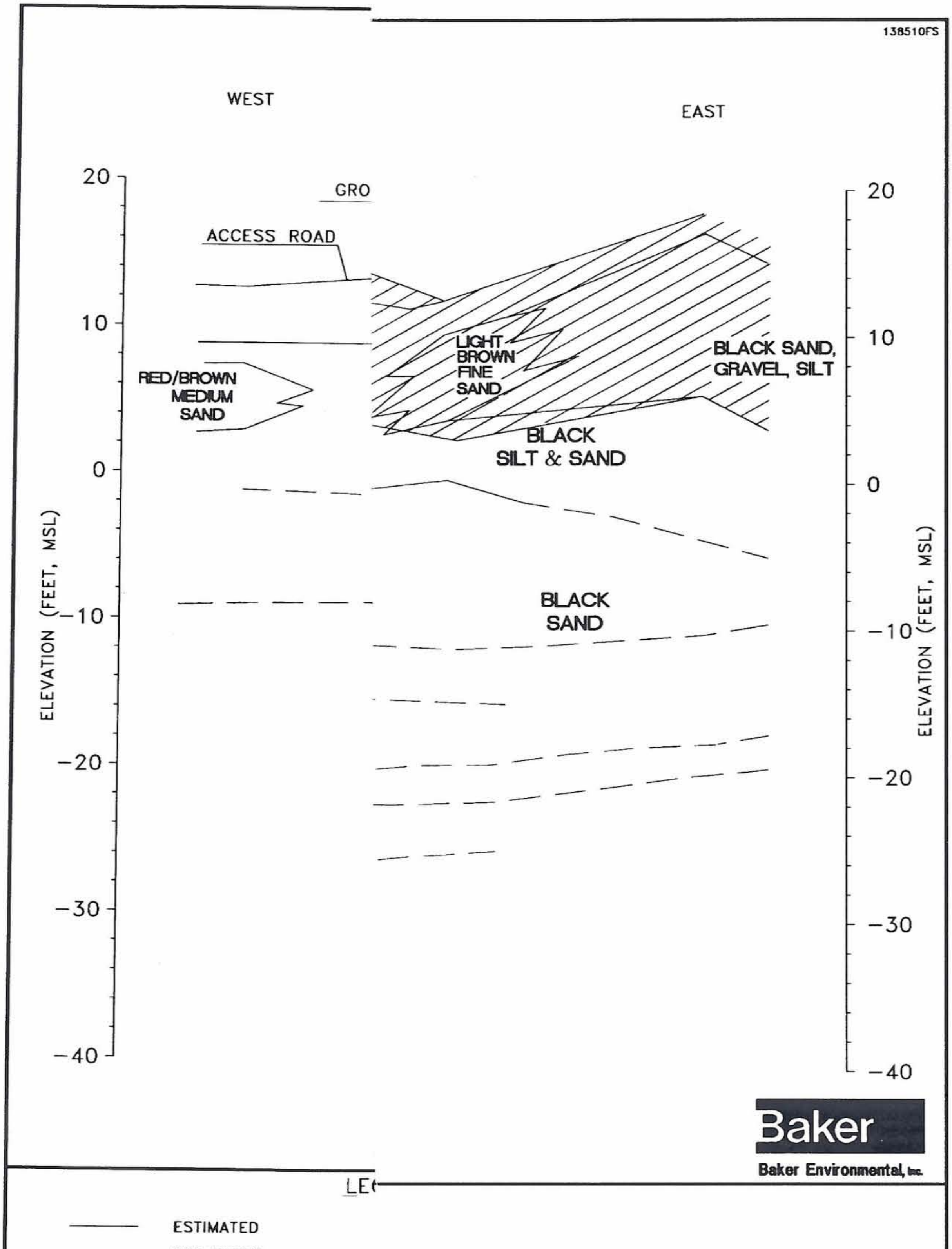


FIGURE 1–3
ALIZED GEOLOGIC CROSS–SECTION
CD LANDFILL

NAVAL BASE NORFOLK
NORFOLK, VIRGINIA

2.0 REMEDIAL ACTION OBJECTIVES

Three media of concern have been identified at the CD Landfill Site as follows:

- Soils (surface and subsurface)
- Sediments
- Groundwater (includes surface water)

For purposes of remedial alternative development in the FS, surface water has been combined with groundwater in Section 5.0.

2.1 General Approach

Applicable, or relevant and appropriate requirements (ARARs), and requirements "to be considered" (TBCs) are used to determine specific cleanup goals and control measures for remedial activities. ARARs and TBCs are discussed in Section 2.2.

Remedial action objectives (RAOs) are developed to protect human health and the environment for medium-specific exposure scenarios. These objectives are developed considering the contaminants of potential concern, potential receptors and exposure scenarios, and acceptable contaminant concentrations for each exposure scenario. Remedial action objectives for the media of concern are identified in Section 2.3. General response actions are then developed in this section to address requirements of the remedial action objectives.

2.2 Applicable, or Relevant and Appropriate Requirements, and Requirements To Be Considered

One of the main considerations during the development of remedial action alternatives for hazardous waste sites under CERCLA is the degree of human health and environmental protection provided by a given remedy. Section 121 of CERCLA requires that primary consideration be given to remedial alternatives that attain or exceed applicable, or relevant and appropriate requirements (ARARs). The purpose of this requirement is to make CERCLA response actions consistent with other pertinent federal and state environmental requirements. ARARs may include the following:

- Any standard, requirement, criterion, or limitation under federal environmental law.

- Any promulgated standard, requirement, criterion, or limitation under a state environmental or facility-citing law that is more stringent than the associated federal standard, requirement, criterion, or limitation.

A requirement may be either "applicable" or "relevant and appropriate," but not both.

Definitions of the two types of ARARs as well as other "to be considered" (TBC) criteria are given below:

- Applicable Requirements means those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that directly and fully address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site.

- Relevant and Appropriate Requirements means those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstances at a CERCLA site, address problems or situations sufficiently similar (relevant) to those encountered at the CERCLA site, that their use is well suited (appropriate) to the particular site. Requirements must be relevant and appropriate to be an ARAR.

- "To be considered" (TBC) criteria are non-promulgated, non-enforceable guidelines or criteria that may be useful for developing remedial action, or necessary for determining what is protective to human health and/or the environment. Examples of TBC criteria include EPA Drinking Water Health Advisories, Carcinogenic Potency Factors, and Reference Doses.

Section 121(d)(4) of CERCLA allows the selection of a remedial alternative that will not attain all ARARs if any of six conditions for a waiver of ARARs exist. These conditions are as follows: (1) the remedial action is an interim measure whereby the final remedy will attain the ARAR upon completion; (2) compliance will result in greater risk to human health and the environment than other options; (3) compliance is technically impracticable; (4) an alternative remedial action will attain the equivalent of the ARAR; (5) for state requirements, the state has not consistently applied the requirement in similar circumstances; (6) compliance with the ARAR will not provide a balance between protecting public health, welfare, and the environment at the facility with the availability of Superfund money for response at other facilities (fund-balancing).

ARARs fall into three categories, based on the manner in which they are applied. The characterization is not perfect, as many requirements are combinations of the three types of ARARs. These categories are as follows:

- Contaminant-Specific: Health-/risk-based numerical values or methodologies that establish concentration or discharge limits for particular contaminants. Examples of contaminant-specific ARARs include Maximum Contaminant Levels (MCLs) and Clean Water Act (CWA) water quality criteria.

- Location-Specific: Restrictions based on the concentration of hazardous substances or the conduct of activities in specific locations. These may restrict or preclude certain remedial actions or may apply only to certain portions of a site. Examples of location-specific ARARs include RCRA location requirements and floodplain management requirements.

- Action-Specific: Technology- or activity-based controls or restrictions on activities related to management of hazardous waste.

In general, the contaminant-specific ARARs and TBCs are considered during the assessment of risks to human health and the environment. These ARARs and TBCs are also considered in the development of remedial action objectives. The action-specific ARARs and TBCs, which affect the implementation and/or operation of the remedial alternatives, are primarily used to assess the feasibility of remedial technologies and alternatives. Potentially pertinent ARARs and TBCs for the CD Landfill Site are summarized in Tables 2-1 and 2-2, respectively.

2.3 Remedial Action Objectives and General Response Actions

2.3.1 Soils

The results of the risk assessment indicate that there would be no unacceptable risks to human health posed by exposure to the surface soils at the CD Landfill under the various current use and potential future use scenarios. However, results of the ecological risk assessment indicate that there may be a potential risk to ecological receptors (i.e., flora and fauna) associated with contaminants in the surface soil.

The results of the risk assessment indicate that there would be unacceptable risks to human health posed by exposure to the subsurface soils at the CD Landfill under the potential future residential use scenario. No unacceptable risks to human health would be posed by exposure to subsurface soils under the construction worker scenario. However, since this site is a former landfill, buried contamination not characterized during the RI may be present within the landfill. Therefore, exposure to potential contamination within the landfill is still a human health concern under a future construction use scenario in which subsurface soils would be disturbed.

Leaching of contaminants from soils to groundwater is the primary concern with respect to potential soil contamination at the site. Specific potential source areas of organic contamination (e.g., chlorobenzene) or inorganic contamination (e.g., lead) were not identified within the landfill during the RI. However, the landfill contains randomly buried waste materials; therefore, unidentified areas of contamination may be present within the landfill, which could serve as current or future sources of groundwater contamination.

Based on the results of the human health and ecological risk assessments, the following remedial action objectives (RAOs) were developed for soils:

1. Prevent human exposure to potential contaminants within subsurface soils and debris.

2. Minimize movement of potential contaminants from soils and debris to groundwater and surface water.

3. Prevent ecological exposure to surface soils.

Based on these RAOs, the following general response actions will be considered in the FS:

- No action
- Institutional controls
- Containment

General response actions involving treatment and/or disposal were not considered since the area is a landfill, and specific, localized areas of contamination, for which these actions might be appropriate, were not identified. For purposes of the FS, institutional controls evaluated for soils will also apply to the sediments contained in the on-site drainage ditches.

Soil cleanup goals were not developed for this site because no "hot spot" areas representing specific sources were identified. The only general response action considered for soils, besides no action and institutional controls, is containment. The entire landfill (eastern and western areas) encompasses an area of approximately 22 acres. Containment actions will be considered for this 22-acre area.

2.3.2 Sediments

As discussed in Section 1.4, contamination in the shallow (0.5 ft. depth) sediments, primarily PAHs, resulted in a slightly unacceptable risk to human health under the various current use and potential future use scenarios. Contamination in the deep (2.0-2.5 ft. depth) sediments did not result in an unacceptable risk to human health under all current and potential future use scenarios. However, results of the ecological risk assessment (Section 1.5) indicate that both shallow and deep sediments may pose a risk to ecological receptors.

Sediment cleanup levels were developed for the adult civilian worker and adult trespasser scenarios, which are shown in Table 2-3. These scenarios are the two most likely exposure scenarios for the site. The adult trespasser cleanup levels would also be protective of child trespassers, since they were developed using a much longer exposure duration. The contaminants shown in Table 2-3 are those that resulted in a human health risk in excess of 1×10^{-4} for carcinogens. The cleanup levels for the carcinogens are based on an ICR of 1×10^{-5} in order to achieve a cumulative risk of 1×10^{-4}.

Sediment cleanup levels for protection of ecological receptors, based on the Effects Range-Low (ER-L) and Effects Range-Median (ER-M) values, are shown in Table 2-4. With the exception of arsenic, both the ER-L and ER-M values are below the risk-based cleanup levels for human health (Table 2-3). Therefore, remediation of the sediments to these levels would also be protective of human health for the civilian worker and trespasser scenarios. Note that the cleanup levels for the organic contaminants shown in Table 2-4 are presented in units of µg/L, whereas the cleanup levels in Table 2-3 are in units of mg/kg. Since the arsenic cleanup level for the civilian worker scenario (24 mg/kg) is less than the ER-M value (70 mg/kg), it will be used in place of the ER-M value to ensure protection of human health.

For the purposes of remedial alternative development, two contaminated sediment volumes were estimated using the ER-L and ER-M cleanup levels. The estimated volumes of sediment exceeding the ER-L and ER-M cleanup levels are 980 cubic yards (CY) and 190 CY, respectively. The contaminated areas in the drainage ditches on which these volumes were based are shown in Figures 2-1 and 2-2 for the ER-L and ER-M cleanup levels, respectively. As shown in Figures 2-1 and 2-2, a depth of 1-foot was assumed for areas of shallow sediment contamination, and a depth of 2.5 feet was assumed for deep sediment contamination. For estimating purposes, an average width of 5 feet was assumed for all drainage ditches.

Based on the results of the human health and ecological risk assessments, the following two RAOs were developed for sediments:

1. Prevent human exposure to contaminated sediment.
2. Prevent ecological exposure to contaminated sediment.

Based on these RAOs, the following general response actions will be considered in the FS:

- No action
- Containment
- Excavation and Off-site Treatment
- Excavation and Off-site Disposal

General response actions involving on-site treatment were not considered because of the relatively small volume of contaminated material and the fact that the sediments contain PAHs, pesticides, PCBs, and a variety of inorganic contaminants. The only well-proven technology for treating the organic contaminants is incineration, which would be cost-prohibitive for on-site treatment. Following incineration, the sediments would then require stabilization (i.e., cement- or silicate-based technologies), which is the only well-proven technology for treatment of metals, in order to render them immobile and unavailable to ecological receptors. Institutional controls for the sediments will be evaluated as part of the soil alternative analysis.

2.3.3 Groundwater

As previously discussed, the shallow (water table) aquifer in the vicinity of the site is not suitable for potable (drinking water) use because of high concentrations of iron, manganese, and total dissolved solids, as well as low pH (less than 6). The deeper Yorktown Aquifer is generally suitable for potable uses, except near tidal waters, which can cause the water to be brackish in quality. Neither the water table or Yorktown Aquifers are currently used for any potable use on site or in the vicinity of the site.

The results of the human health risk assessment indicate that there would be no unacceptable human health risk if the Yorktown Aquifer was to be used for either potable or nonpotable purposes. However, the site is a landfill which contains potential sources of contamination. Therefore, installation of potable supply wells on or adjacent to the landfill could pose a future threat to human health.

With respect to the shallow groundwater, the most likely potential beneficial uses of this aquifer are nonpotable uses such as lawn watering and vehicle washing by civilian workers. As discussed in Section 1.5, the major contaminant contributing to the risk under this exposure scenario is chlorobenzene. Chlorobenzene was detected in monitoring well MW-05A during sampling rounds 1 and 2 at concentrations of 1,950 µg/L and 1,000 µg/L, respectively. In addition to chlorobenzene, 1,4-dichlorobenzene was detected in monitoring well MW-05A and in two surface water samples. Therefore, this contaminant will also be considered a contaminant of concern for the FS. Although Aroclor 1260 resulted in a slight carcinogenic risk (ICR = 7.7×10^{-4}), it is not considered a contaminant of concern for the FS since it was only detected in one monitoring well during sampling round two at a concentration of 0.12 µg/L. This one detection may have been the result of turbidity (i.e., suspended solids) in the well, since PCBs are relatively insoluble and are seldomly detected in groundwater in the dissolved phase. In addition to Aroclor 1260, the pesticide, dieldrin, was detected during sampling round 2 in monitoring wells MW-02B and MW-03B at concentrations of 0.006 µg/L and 0.015 µg/L, respectively. Dieldrin is not considered a contaminant of concern for the FS since it was only detected in these two wells and at very low concentrations. Similarly to PCBs, the dieldrin detections may have been the result of turbidity (i.e., suspended solids) in the well.

The following cleanup levels were developed for chlorobenzene and 1,4-dichlorobenzene based on the nonpotable use scenario (accidental ingestion and dermal contact exposure routes):

- chlorobenzene: 100 µg/L
- 1,4-dichlorobenzene: 20 µg/L

The cleanup level for the 1,4-dichlorobenzene is based on an ICR of 1×10^{-5}. The chlorobenzene cleanup level is based on an HI of 0.1. Above cleanup levels should be protective of surface water since they are below their respective federal Ambient Water Quality Criteria (AWQC) (57FR60920-60921) and Virginia Water Quality Standards (UR 680-21-01.14).

Based on the results of the human health and ecological risk assessments, the following RAOs were developed for groundwater:

1. Prevent exposure (ingestion and dermal contact) to shallow groundwater exceeding nonpotable use cleanup levels.

2. Prevent migration of shallow groundwater exceeding nonpotable use cleanup levels.

3. Restore shallow groundwater to nonpotable use cleanup levels.

4. Prevent discharge of contaminated shallow groundwater to surface water.

5. Prevent future potable use of the Yorktown Aquifer on site.

The following general response actions will be considered for groundwater:

- No action
- Institutional controls (includes monitoring)
- Containment
- In situ Treatment
- Extraction, On-site Treatment, and Discharge

TABLE 2-1a

POTENTIAL FEDERAL CHEMICAL-SPECIFIC ARARS BY MEDIA
CD LANDFILL SITE
NAVAL BASE, NORFOLK, VIRGINIA
(Sheet 1 of 3)

Requirement	Prerequisite	Citation	ARAR Determination	Comments
GROUNDWATER				
Safe Drinking Water Act (SDWA), 42 USC 300*				
National primary drinking water standards are health-based standards for public water systems (maximum contaminant levels [MCLs]).	Public water system.	40 CFR 141.11 -141.16, excluding 141.11(d)(3); 40 CFR 141.60 -141.63	Relevant and appropriate for Yorktown Aquifer only, which is a Class II aquifer. The water table aquifer is a Class III aquifer.	MCLs are relevant and appropriate for groundwater determined to be a current or potential source of drinking water in cases where MCLGs are not ARARs. MCLs are relevant and appropriate for Class I and Class II aquifers, but not for Class III aquifers. Relevant and appropriate at the unit boundary. No contaminants detected in Yorktown Aquifer in excess of MCLs.
Maximum contaminant level goals [MCLGs] pertain to known or anticipated adverse health effects (also known as recommended maximum contaminant levels).	Public water system.	Public Law No. 99-339 100 Statute 642 (1986) 40 CFR 141 Subpart F	Relevant and appropriate for Yorktown Aquifer only, which is a Class II aquifer. The water table aquifer is a Class III aquifer.	MCLGs that have non-zero values are relevant and appropriate for groundwater determined to be a current or potential source of drinking water (40 CFR 300.430[e][2][i][B] through [D]). Relevant and appropriate at the unit boundary.

TABLE 2-1a

POTENTIAL FEDERAL CHEMICAL-SPECIFIC ARARS BY MEDIA
CD LANDFILL SITE
NAVAL BASE, NORFOLK, VIRGINIA
(Sheet 2 of 3)

Requirement	Prerequisite	Citation	ARAR Determination	Comments
National secondary drinking water regulations are standards for the aesthetic qualities of public water systems (secondary MCLs [SMCLs]).	Public water system.	40 CFR 143, excluding 143.5(b)	TBC for Yorktown Aquifer only.	SMCLs are nonenforceable federal contaminant levels intended as guidelines for the states. Because they are nonenforceable, federal SMCLs are not ARARs. However, they may be TBCs at the unit boundary. Iron and manganese detected above SMCLs in two Yorktown Aquifer wells (may not be site-related). Iron SMCL = 300 µg/L, Manganese SMCL = 50 µg/L.
SURFACE WATER				
Clean Water Act (CWA), 33 USC 1251 et seq.*				
Water quality standards.	Discharges to waters of the United States.	33 USC 1313 and 57 Federal Register 60920-60921	Applicable.	Federal water quality standards would be applicable for any discharges to surface water (from contaminated groundwater or surface runoff).

TABLE 2-1a

POTENTIAL FEDERAL CHEMICAL-SPECIFIC ARARS BY MEDIA
CD LANDFILL SITE
NAVAL BASE, NORFOLK, VIRGINIA
(Sheet 3 of 3)

Requirement	Prerequisite	Citation	ARAR Determination	Comments
Water quality criteria.	Discharges to waters of the United States and groundwater.	33 USC 1314(a) and 42 USC 9621(d)(2)	Relevant and appropriate.	Federal water quality standards may be relevant and appropriate for any discharges to surface water (from contaminated groundwater or surface runoff).
AIR				
Clean Air Act (CAA), 40 USC 7401 et seq.*				
National Ambient Air Quality Standards (NAAQS): *Primary and secondary standards* for ambient air quality to protect public health and welfare (including standards for particulate matter and lead).	Contamination of air affecting public health and welfare.	40 CFR 50.4 - 50.12	TBC	Not enforceable and therefore not an ARAR. May be a TBC.

* Statutes and policies, and their citations, are provided as headings to identify general categories of potential ARARs for the convenience of the reader. Listing the statutes and policies does not indicate that DON accepts the entire statutes or policies as potential ARARs. Specific potential ARARs are addressed in the table below each general heading; only substantive requirements of the specific citations are considered potential ARARs.

ARARs - Applicable or relevant and appropriate requirements.
CFR - Code of Federal Regulations.
USC - United States Code.
TBC - To be considered.

TABLE 2-1b

POTENTIAL FEDERAL LOCATION-SPECIFIC ARARS
CD LANDFILL SITE
NAVAL BASE, NORFOLK, VIRGINIA
(Sheet 1 of 1)

Location	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Executive Order 11988, Protection of Floodplains*					
Within floodplain	Actions taken should avoid adverse effects, minimize potential harm, restore and preserve natural and beneficial values.	Action that will occur in a floodplain, i.e., lowlands, and relatively flat areas adjoining inland and coastal waters and other flood-prone areas.	40 CFR 6, Appendix A; excluding Sections 6(a)(2), 6(a)(4), 6(a)(6); 40 CFR 6.302	Applicable.	Regrading activities may require compliance with this order.
Executive Order 11990, Protection of Wetlands*					
Wetland	Action to minimize the destruction, loss, or degradation of wetlands.	Wetland as defined by Executive Order 11990 Section 7.	40 CFR 6, Appendix A; excluding Sections 6(a)(2), 6(a)(4), 6(a)(6); 40 CFR 6.302	Relevant and appropriate.	Wetlands are present on and near the site which could be impacted by response actions for the site.
Clean Water Act, Section 404*					
Wetland	Action to prohibit discharge of dredged or fill material into wetland without permit.	Wetland as defined by Executive Order 11990 Section 7.	40 CFR 230.10; 40 CFR 231 (231.1, 231.2, 231.7, 231.8)	Relevant and appropriate.	This requirement would be an ARAR if discharge of dredged or fill material to a wetland is planned as part of the response action.

* Statutes and policies, and their citations, are provided as headings to identify general categories of potential ARARs for the convenience of the reader. Listing the statutes and policies does not indicate that DON accepts the entire statues or policies as potential ARARs. Specific potential ARARs are addressed in the table below each general heading; only substantive requirements of the specific citations are considered potential ARARs.

ARARs - Applicable or relevant and appropriate requirements.
CFR - Code of Federal Regulations.
USC - United States Code.

TABLE 2-1c

POTENTIAL FEDERAL ACTION-SPECIFIC ARARS
CD LANDFILL SITE
NAVAL BASE, NORFOLK, VIRGINIA
(Sheet 1 of 1)

Action	Requirement	Prerequisites	Citation	ARAR Determination**			Comments
				A	RA	TBC	
Resource Conservation and Recovery Act (RCRA) *Subtitle C*							
Closure of Landfill	Closure and postclosure care requirements for hazardous waste landfills.	Landfill used to dispose hazardous waste.	40 CFR 264.310		X		Relevant and appropriate to permitted section of the landfill since disposal of EP toxic waste for cadmium (D006) occurred after November 1980.
RCRA Subtitle D*							
Closure of Landfill	Provides recommended procedures for cover material.	Landfill used to dispose solid wastes.	40 CFR Part 241			X	A TBC for unpermitted section of landfill which operated from 1974 to 1979.
Off-site Disposal	Provides criteria for determining if solid waste disposal facility poses an adverse effect on human health or environment.	Permitted solid waste landfill.	40 CFR Part 257			X	A TBC for determining suitable off-site disposal facilities.
Off-site Disposal	Provides criteria for determining if municipal solid waste disposal facility poses an adverse effect on human health or environment.	Permitted municipal solid waste landfill.	40 CFR Part 258			X	A TBC for determining suitable off-site disposal facilities.
Clean Air Act (CAA) 40 USC 7401 et seq.*							
Discharge to air	National Primary and Secondary Ambient Air Quality Standards (NAAQS) - standards for ambient air quality to protect public health and welfare (including standards for particulate matter and lead).	Contamination of air affecting public health and welfare	40 CFR Sections 50.4 - 50.12			X	Not an ARAR; Federal NAAQS are nonenforceable standards. May be a TBC for regrading activities.

*Statutes and policies, and their citations, are provided as headings to identify general categories of potential ARARs. Specific potential ARARs are addressed in the table below each general heading.

** A - Applicable, RA - Relevant and appropriate, TBC - To be considered

ARAR - Applicable or relevant and appropriate requirement.
CFR - Code of Federal Regulations.
USC - United States Code.
NAAQS - National Ambient Air Quality Standards (primary and secondary).

TABLE 2-2a

POTENTIAL VIRGINIA CHEMICAL-SPECIFIC ARARS BY MEDIA
CD LANDFILL SITE
NAVAL BASE, NORFOLK, VIRGINIA
(Sheet 1 of 2)

Requirement	Prerequisite	Citation	ARAR Determination	Comments
GROUNDWATER				
Virginia Drinking Water Standards, Virginia Department of Health Waterworks Regulations VR 355-18-004*				
Primary drinking water standards are health-based standards for public water systems (maximum contaminant levels [MCLs]).	Public water system.	VR 355-18-004.06	Relevant and appropriate for the Yorktown Aquifer only, which is a Class II aquifer. Water table aquifer is a Class III aquifer.	Virginia MCLs are identical to federal MCLs. MCLs are relevant and appropriate for groundwater determined to be a current or potential source of drinking water in cases where MCLGs are not ARARs. MCLs are relevant and appropriate for Class I and Class II aquifers, but not for Class III aquifers. Relevant and appropriate at the unit boundary. No contaminants detected in Yorktown Aquifer in excess of MCLs.
Secondary drinking water regulations are standards for the aesthetic qualities of public water systems (secondary MCLs [SMCLs]).	Public water system.	VR 355-18-004.06	TBC for Yorktown Aquifer only.	Virginia SMCLs are similar to federal SMCLs. SMCLs are nonenforceable contaminant levels. Because they are nonenforceable, SMCLs are not ARARs. However, they may be TBCs. Iron and manganese detected above SMCLs in two Yorktown Aquifer wells (may not be site-related). Iron SMCL = 300 µg/L, Manganese SMCL = 50 µg/L.
Virginia Groundwater Standards VR 680-21-04*				
Establishes groundwater standards for State Antidegradation Policy.	Standards are used when no MCL is available.	VR 680-21-04.3	Relevant and appropriate when MCL not available.	MCLs available for all contaminants of concern.
SURFACE WATER				
Virginia Water Quality Standards VR 680-21-00*				
Water quality standards based on water use and class of surface water.	Discharges to surface waters.	VR 680-21-01.14	Applicable.	Water quality standards would be applicable for any discharges to surface water (from contaminated groundwater or surface runoff).

TABLE 2-2a

POTENTIAL VIRGINIA CHEMICAL-SPECIFIC ARARS BY MEDIA
CD LANDFILL SITE
NAVAL BASE, NORFOLK, VIRGINIA
(Sheet 2 of 2)

Requirement	Prerequisite	Citation	ARAR Determination	Comments
AIR				
Virginia Air Pollution Control Regulations				
Ambient Air Quality Standards: Primary and secondary standards for ambient air quality to protect public health and welfare (including standards for particulate matter and lead).	Contamination of air affecting public health and welfare.	VR 120-03-02, 120-03-06, and 120-05-0104	Applicable	Not enforceable and therefore not an ARAR. May be a TBC.

* Statutes and policies, and their citations, are provided as headings to identify general categories of potential ARARs for the convenience of the reader. Listing the statutes and policies does not indicate that DON accepts the entire statutes or policies as potential ARARs. Specific potential ARARs are addressed in the table below each general heading; only substantive requirements of the specific citations are considered potential ARARs.

ARARs - Applicable or relevant and appropriate requirements.
CFR - Code of Federal Regulations.
USC - United States Code.
TBC - To be considered criterion, not an ARAR

TABLE 2-2b

POTENTIAL VIRGINIA LOCATION-SPECIFIC ARARs
CD LANDFILL SITE
NAVAL BASE, NORFOLK, VIRGINIA

Location	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Virginia Wetlands Act and Virginia Wetlands Regulations*					
Wetland	Action to minimize the destruction, loss, or degradation of wetlands.	Wetland as defined by Executive Order 11990 Section 7.	Code of Virginia Sections 62.1-13.1 et seq. and VR 450-01-0051	Applicable	Wetlands are present on and adjacent to the site which could be impacted by the response action for the site.
Chesapeake Bay Preservation Act and Chesapeake Bay Preservation Area Designation and Management Regulations*					
Chesapeake Bay areas	Under these requirement, certain locally designated tidal and nontidal wetlands, as well as other sensitive land areas, may be subject to limitations regarding land-disturbing activities, removal of vegetation, use of impervious cover, erosion and sediment control, stormwater management, and other aspects of land use that may have effects on water quality.	Federally owned area designated as a Chesapeake Bay Preservation area.	Code of Virginia Section 10.1-2100 et seq. and VR 173-02-01	TBC	This requirement is not an ARAR since the area affected by the response action is not a federally owned Chesapeake Bay Preservation area. Also, City of Norfolk does not have jurisdiction over the Naval Base. compliance is on a voluntary basis.
Coastal Zone Management Act*; Coastal Management Plan, City of Norfolk, NOAA Regulations on Federal Consistency with approved State Coastal Zone Management Programs					
Within coastal zone	Conduct activities within a coastal Management Zone in a manner consistent with local requirements.	Activities affecting the coastal zone including lands thereunder and adjacent shoreland.	Section 307(c) of 16 USC 1456(c); also see 15 CFR 930 and 923.45	TBC	This requirement is not an ARAR since the City of Norfolk does not have jurisdiction over the Naval Base. Compliance is on a voluntary basis.

* Statutes and policies, and their citations, are provided as headings to identify general categories of potential ARARs for the convenience of the reader. Listing the statutes and policies does not indicate that DON accepts the entire statues or policies as potential ARARs. Specific potential ARARs are addressed in the table below each general heading; only substantive requirements of the specific citations are considered potential ARARs.

ARARs - Applicable or relevant and appropriate requirements.

TABLE 2-2c

POTENTIAL VIRGINIA ACTION-SPECIFIC ARARS
CD LANDFILL SITE
NAVAL BASE, NORFOLK, VIRGINIA
(Sheet 1 of 2)

Action	Requirement	Prerequisites	Citation	ARAR Determination**			Comments
				A	RA	TBC	
Virginia Hazardous Waste Management Regulations*							
Closure of Landfill	Closure and post-closure care requirements for hazardous waste landfill.	Landfill used to dispose hazardous waste.	VR 672-10-01, Part X, Section 10.13.K	X			Applicable to permitted section of the landfill since disposal of EP toxic waste for cadmium (D006) occurred after November 1980.
Virginia Air Pollution Control Regulations*							
Discharge to air	Virginia Ambient Air Quality Standards - standards for ambient air quality to protect public health and welfare (including standards for particulate matter and lead).	Contamination of air affecting public health and welfare.	VR 120-03-02, VR 120-03-06	X			Applicable for regrading activities.
Discharge of visible emissions and fugitive dust	Fugitive dust/emissions may not be discharged to the atmosphere at amounts in excess of standards.	Any source of fugitive dust/ emissions.	VR 120-05-0104	X			Applicable for regrading activities.
Discharge of toxic pollutants	Toxic pollutants may not be discharged to the atmosphere at amounts in excess of standards.	Any emission from the disturbance of soil, or treatment of soil or water, that do not qualify for the exemptions under Rule 4-3.	VR 120-05-0104	X			Applicable for regrading activities.

TABLE 2-2c

POTENTIAL VIRGINIA ACTION-SPECIFIC ARARS
CD LANDFILL SITE
NAVAL BASE, NORFOLK, VIRGINIA
(Sheet 2 of 2)

Action	Requirement	Prerequisites	Citation	ARAR Determination**			Comments
				A	RA	TBC	
Virginia Stormwater Management Regulations and Virginia Erosion and Sediment Control Regulations							
Stormwater Management	Regulates stormwater management and erosion/sedimentation control practice.	Land disturbing activities.	VR 215-02-00 VR 625-02-00	X			DON has authority for approval of sediment and erosion control plan.
Virginia Solid Waste Regulations VR 672-20-10*							
Closure of Construction/ Demolition Debris Landfills	Closure and post-closure care requirements for construction/demolition debris landfills.	Landfill used to dispose construction/demolition debris.	VR 672-20-10, Part V, Section 5.2.E		X		Relevant and appropriate for unpermitted section of landfill which operated from 1974 to 1979.
Virginia Water Pollution Control Regulations and Water Protection Permit Regulations*							
Discharge of Treated Water to Surface Waters	Regulated point-source discharges through VPDES permitting program. Permit requirements include compliance with corresponding water quality standards, establishment of a discharge monitoring system, and completion of regular discharge monitoring records.	Applicable to discharge of treated water to surface water.	VR 680-14-01, VR 680-15-01	X			Substantive requirements of VPDES permit will be used to determine the discharge limits for the discharge of the treated water to surface water on site.
Virginia Regulations for the Transportation of Hazardous Materials							
Hazardous Materials Preparation and Transportation	Hazardous materials must be packaged, marked, labeled, placarded, and transported in the manner required.	Intrastate carriers transporting hazardous waste and substances by motor vehicle.	VR 672-10-01 Parts VI and VII VR 672-30-1	X			Applicable for preparation and off-site transportation of materials classified as hazardous.

TABLE 2-2c

POTENTIAL VIRGINIA ACTION-SPECIFIC ARARS
CD LANDFILL SITE
NAVAL BASE, NORFOLK, VIRGINIA
(Sheet 3 of 2)

Action	Requirement	Prerequisites	Citation	ARAR Determination**			Comments
				A	RA	TBC	
Virginia Solid Waste Regulations VR 672-20-10*							
Solid Waste Disposal	*Disposal facility must be properly* permitted and in compliance with all operational and monitoring requirements of the permit and regulations.	Solid waste disposal facility and practices except agricultural wastes, overburden resulting from mining operations, land application of domestic sewage, location and operations of septic tanks, solid or dissolved materials in irrigation return flows, industrial discharges that are point sources subject to permits under CWA, source special nuclear or by-product material as defined by the Atomic Energy Act, solid waste disposal facilities that are subject to regulation under RCRA Subtitle D, disposal of Solid Waste by underground well injection, and municipal solid waste landfill units.	VR 672-20-10, Part V	X			Applicable to off-site disposal of any soil, debris, sludge, or other material classified as a solid waste.

*Statutes and policies, and their citations, are provided as headings to identify general categories of potential ARARs. Specific potential ARARs are addressed in the table below each general heading.

** A - Applicable, RA - Relevant and appropriate, TBC - To be considered

ARAR - Applicable or relevant and appropriate requirement.
CFR - Code of Federal Regulations.
USC - United States Code.
VPDES - Virginia Pollutant Discharge Elimination System.

TABLE 2-3

RISK-BASED SEDIMENT CLEANUP LEVELS
CIVILIAN WORKER AND TRESPASSER SCENARIOS
CD LANDFILL SITE
NAVAL BASE, NORFOLK, VIRGINIA

Contaminant	Cleanup Levels[1] Carcinogens (mg/kg)	
	Trespasser[2]	Civilian Worker[3]
Benzo(a)anthracene	42	11
Benzo(b)fluoranthene	42	11
Benzo(a)pyrene	4.2	1.1
Chrysene	467	113
Dibenzo(a,h)anthracene	4.2	1.1
Ideno(1,2,3-cd)anthracene	42	11
Dieldrin	2	0.5
Arsenic	78	24

(1) Based on a 1 x 10^{-5} incremental cancer risk.

(2) Based on evaluation of future adult trespasser exposures to shallow sediment via the combined pathways of accidental ingestion and dermal contact.

(3) Based on evaluation of future civilian worker (grounds keeper) exposures to shallow sediment via the combined pathways of accidental ingestion and dermal contact.

NA = Not Applicable

TABLE 2-4

ECOLOGICAL-BASED SEDIMENT CLEANUP LEVELS
CD LANDFILL SITE
NAVAL BASE NORFOLK, VIRGINIA

Contaminant	Sediment Cleanup Levels	
	ER-L	ER-M
Volatiles (µg/kg)		
Acetone	NE	NE
2-Butanone	NE	NE
Chlorobenzene	NE	NE
1,2-Dichloroethene (total)	NE	NE
Methylene Chloride	NE	NE
Trichloroethene	NE	NE
Semivolatiles (µg/kg)		
Acenaphthylene	44[4]	640[1]
Acenaphthene	16[4]	500[1]
Anthracene	85.3[1]	1,100[1]
Benzo(a)anthracene	261[4]	1,600[1]
Benzo(b)fluoranthene	3,200[4]	NE
Benzo(k)fluoranthene	3,200[5]	NE
Benzo(g,h,i)perylene	670[4]	NE
Benzo(a)pyrene	430[4]	1,600[1]
Butylbenzylphthalate	5,300[4]	NE
Carbazole	NE	NE
Chrysene	384[4]	2,800[1]
Dibenzofuran	540[5]	NE
Dibenz(a,h)anthracene	63.4[4]	260[1]
1,2-Dichlorobenzene	35[4]	NE
1,3-Dichlorobenzene	>170[5]	NE
1,4-Dichlorobenzene	110[4]	NE
Fluorene	19[4]	540[1]
Fluoranthene	600[4]	5,100[1]
Indeno(1,2,3-cd)pyrene	600[4]	NE
2-Methylnaphthalene	70[4]	670[1]
Naphthalene	160[4]	2,100[1]
Phenanthrene	240[4]	1,500[1]
Phenol	420[5]	NE
Pyrene	665[4]	2,600[1]
1,2,4-Trichlorobenzene	31[5]	NE

TABLE 2-4 (Continued)

ECOLOGICAL-BASED SEDIMENT CLEANUP LEVELS
CD LANDFILL SITE
NAVAL BASE NORFOLK, VIRGINIA

Contaminant	Sediment Cleanup Levels	
	ER-L	ER-M
Pesticides/PCBs (µg/kg)		
beta-BHC	NE	NE
4,4'-DDD	2[2]	20[2]
4,4'-DDE	2.2[4]	27[1]
4,4'-DDT	1[2]	7[2]
Alpha-chlordane	0.5[2]	6[2]
Gamma-chlordane	0.5[2]	6[2]
Dieldrin	0.02[2]	8[2]
Endrin aldehyde	NE	NE
Heptachlor epoxide	NE	NE
Aroclor 1248	22.7[3][4]	180[1][3]
Aroclor 1254	22.7[3][4]	180[1][3]
Aroclor 1260	22.7[3][4]	180[1][3]
Inorganics (mg/kg)		
Aluminum	NE	NE
Antimony	3.2[5]	NE
Arsenic	8.2[1]	70[1]
Barium	500[6]	NE
Beryllium	0.36[5]	NE
Cadmium	1.2[1]	9.6[1]
Calcium	NE	NE
Chromium	81[1]	370[1]
Cobalt	NE	NE
Copper	34[1]	270[1]
Iron	27,000[5]	NE
Lead	46.7[1]	218[1]
Magnesium	NE	NE
Manganese	230[5]	NE
Mercury	0.15[1]	0.71[1]
Nickel	20.9[1]	51.6[1]
Potassium	NE	NE
Selenium	1.0[5]	NE

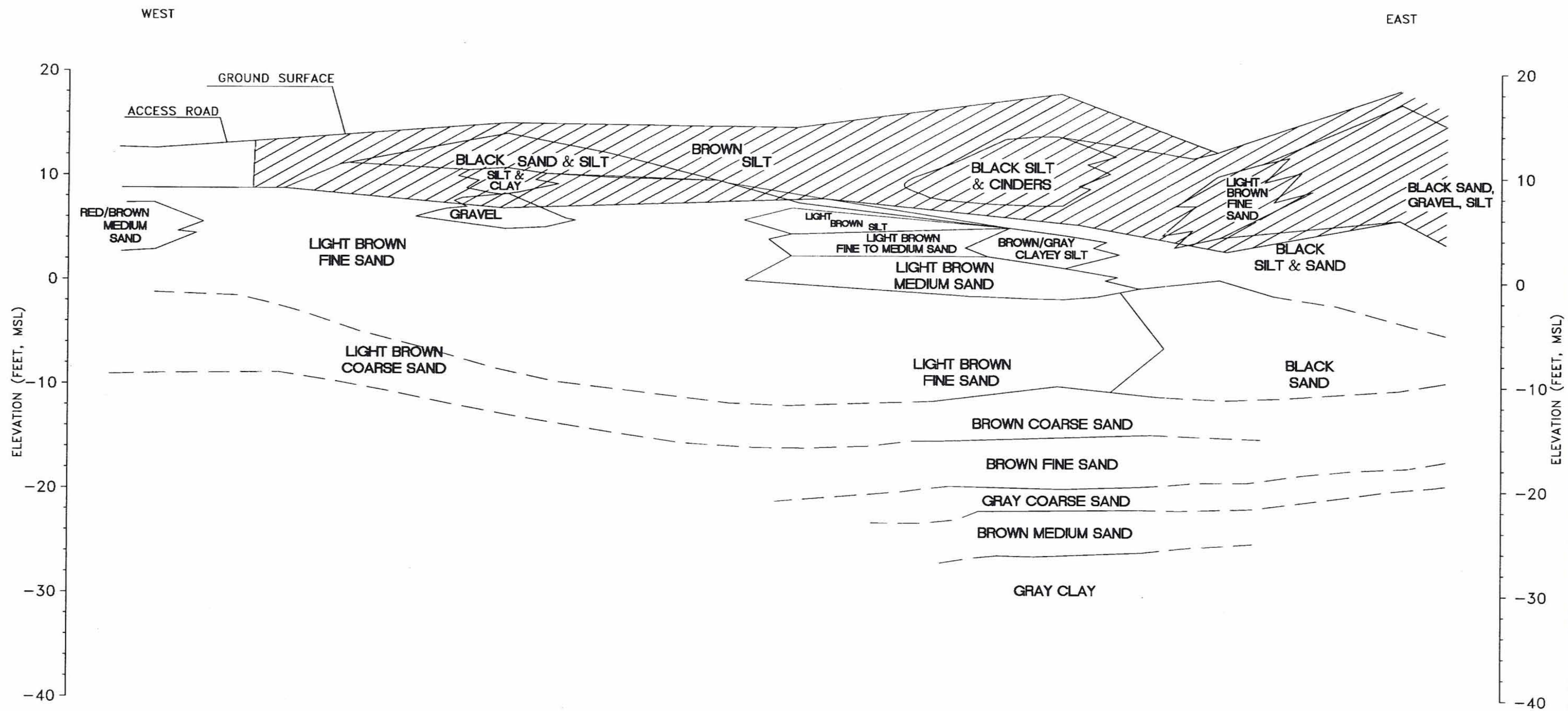
TABLE 2-4 (Continued)

ECOLOGICAL-BASED SEDIMENT CLEANUP LEVELS
CD LANDFILL SITE
NAVAL BASE NORFOLK, VIRGINIA

Contaminant	Sediment Cleanup Levels	
	ER-L	ER-M
Silver	1(1)	3.7(1)
Sodium	NE	NE
Thallium	0.24(5)	NE
Vanadium	NE	NE
Zinc	150(1)	410(1)

NE = Not Established
ER-L - Effects Range Low
ER-M - Effects Range Median

(1) Long et.al., 1995
(2) Long and Morgan, 1991
(3) Value for total PCBs
(4) Region III BTAG Screening Value for Sediment
(5) Tetra Tech Inc., 1986 (Apparent Effects Threshold Sediment Quality Values)
(6) Sulliven et.al., 1985



Baker

Baker Environmental, Inc.

LEGEND

———	ESTIMATED
— — —	PROJECTED
▨	FILL MATERIAL

150 0 75 150 300

Horizontal Scale: 1 inch = 150 ft.

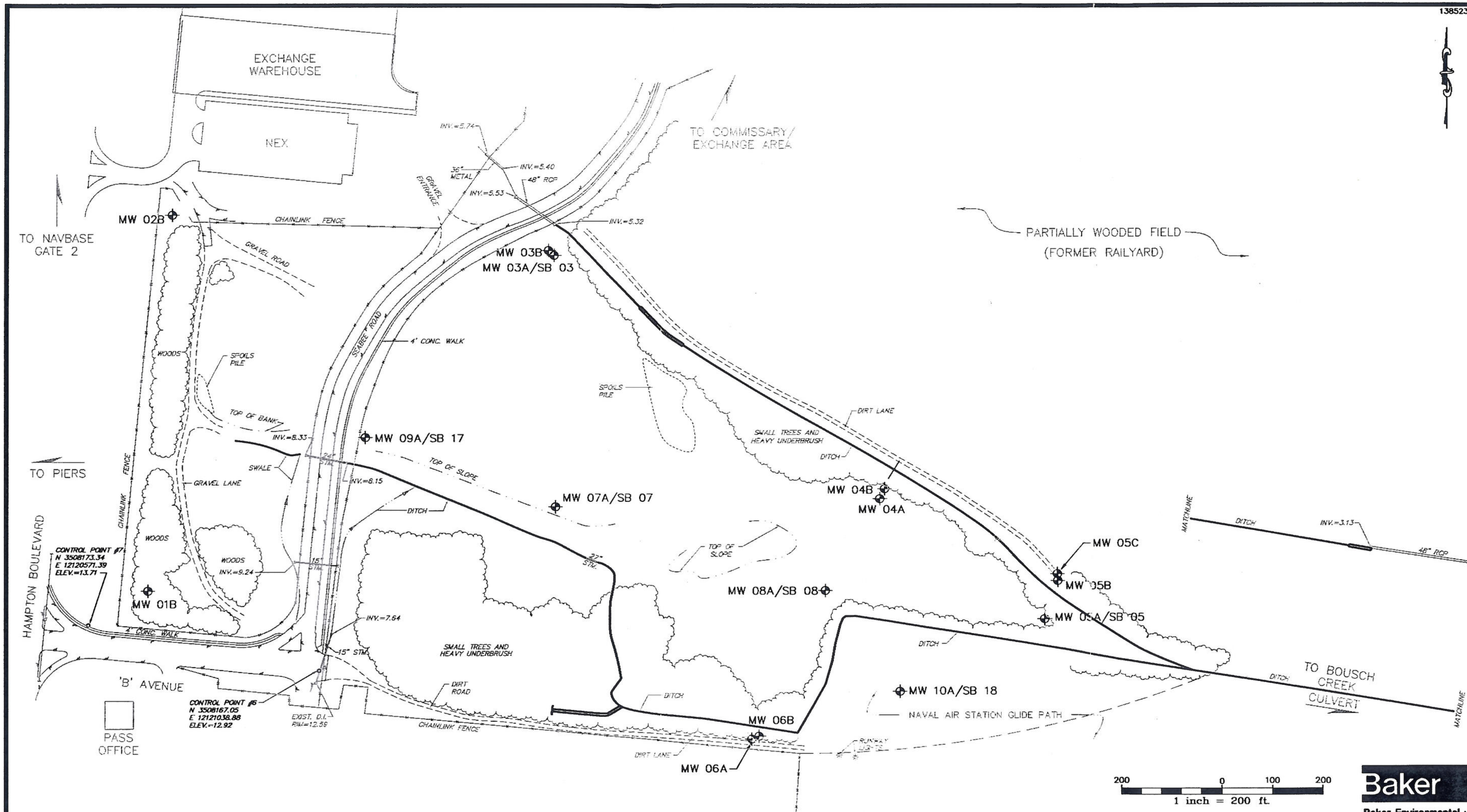
10 0 5 10 20

Vertical Scale: 1 inch = 10 ft.

THE SOIL BORING INFORMATION IS CONSIDERED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT THE RESPECTIVE BORING LOCATIONS. SUBSURFACE CONDITIONS INTERPOLATED BETWEEN BORINGS ARE ESTIMATED BASED ON ACCEPTED SOIL ENGINEERING PRINCIPLES AND GEOLOGIC JUDGEMENT.

FIGURE 1-3
GENERALIZED GEOLOGIC CROSS-SECTION
CD LANDFILL

NAVAL BASE NORFOLK
NORFOLK, VIRGINIA



LEGEND

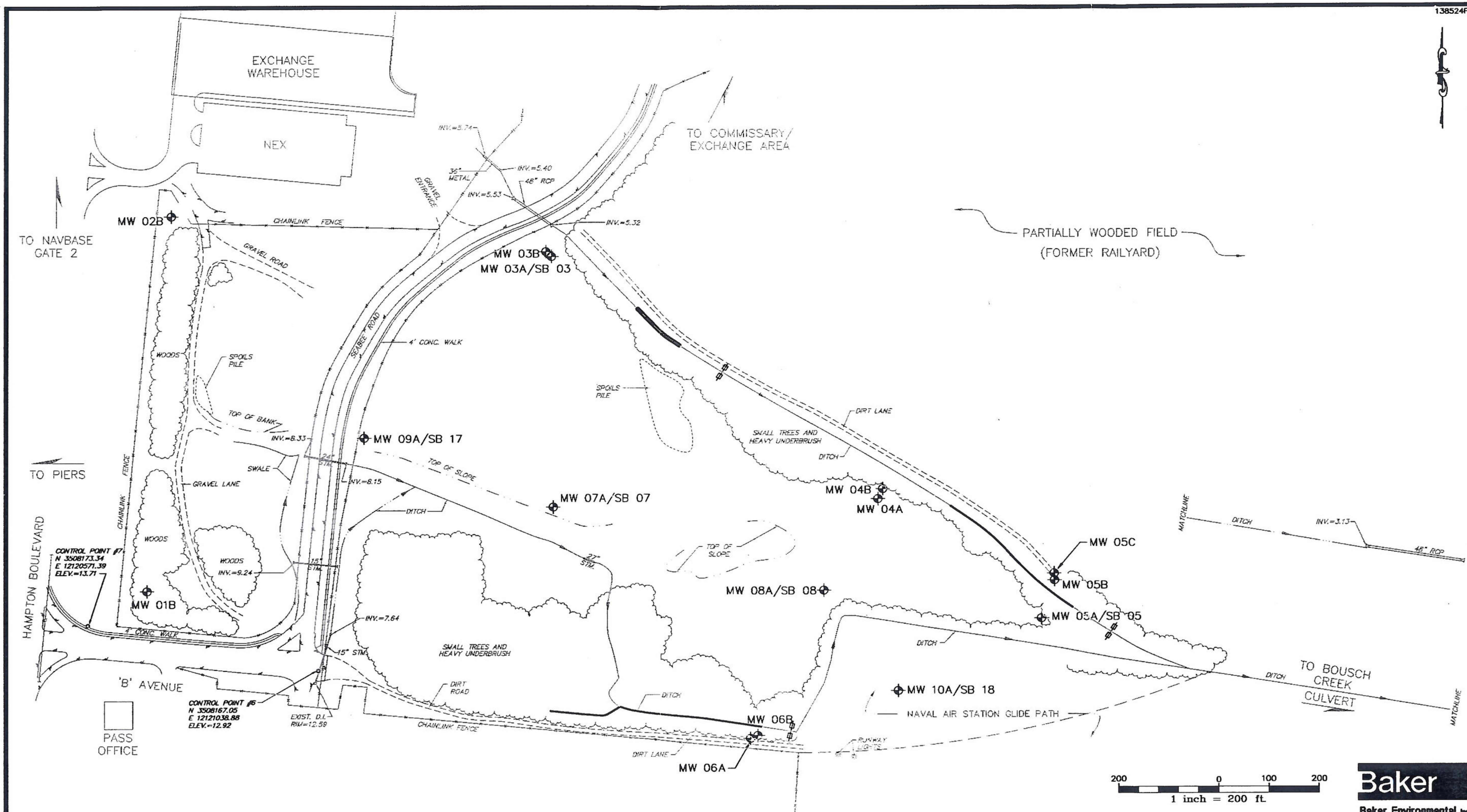
MW 01 EXISTING MONITORING WELL (AND ASSOCIATED BORING) LOCATION

APPROXIMATE LIMITS OF SHALLOW SEDIMENT REMOVAL (1' REMOVAL DEPTH)

APPROXIMATE LIMITS OF DEEP SEDIMENT REMOVAL (1' TO 2.5' REMOVAL DEPTH)

SOURCE: HOGGARD/EURE, SEPTEMBER 1993

FIGURE 2-1
ALTERNATIVE SD-2A: SEDIMENT EXCEEDING ER-Ls REMOVAL AND OFF-SITE DISPOSAL
CD LANDFILL
NAVAL BASE NORFOLK
NORFOLK, VIRGINIA



LEGEND

- MW 01 EXISTING MONITORING WELL (AND ASSOCIATED BORING) LOCATION
- APPROXIMATE LIMITS OF SHALLOW SEDIMENT REMOVAL (1' REMOVAL DEPTH)
- APPROXIMATE LIMITS OF DEEP SEDIMENT REMOVAL (1' TO 2.5' REMOVAL DEPTH)
- STRAW BALES

SOURCE: HOGGARD/EURE, SEPTEMBER 1993

FIGURE 2-2
ALTERNATIVE SD-2B: SEDIMENT EXCEEDING ER-Ms REMOVAL AND OFF-SITE DISPOSAL
CD LANDFILL
NAVAL BASE NORFOLK
NORFOLK, VIRGINIA

3.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS

This section includes the identification and screening of remedial technologies and associated process options that may be applicable for remediation of contaminated soils, sediment, and groundwater at the CD Landfill Site. The technologies and process options have been organized according to the general response actions developed in Section 2.3.

The identification and screening of remedial technologies and process options are provided in Sections 3.1 and 3.2 for soils and sediments, respectively. Section 3.3 contains the identification and screening of technologies and process options for groundwater. For purposes of the FS, surface water has been included under the groundwater category. In each section, the identification and screening of technologies and process options is conducted to evaluate their overall applicability to the site contaminants as well as their general implementability to site-specific conditions and cost-effective. Based on the screening, the retained technologies and process options are assembled into remedial alternatives in Sections 4.0, 5.0, and 6.0 for soils, groundwater, and sediment, respectively. Where appropriate, representative process options are selected for the alternative analysis.

3.1 Identification and Screening of Technologies and Process Options for Soils

The initial identification and screening of potentially applicable soil technologies and process options is presented in Table 3-1. The results of the technology and process option screening is presented in Table 3-2. As shown in Table 3-2, a composite cap was selected as a representative process option for low-permeability capping technology. Representative process options are chosen to represent the technologies in the development of remedial alternatives. A representative process option does not necessarily reflect a preference for that process, but rather is selected to simplify development and evaluation of remedial alternatives in the FS. Other process options for a given technology could be considered during a remedial design phase.

The following soil remedial alternatives were developed using the retained soil technologies and representative process options:

- Alternative SO-1: No Action
- Alternative SO-2: Institutional Controls
- Alternative SO-3: Soil Cap with Institutional Controls
- Alternative SO-4: Composite Cap with Institutional Controls

The above alternatives are described and evaluated in Section 4.0.

3.2 Identification and Screening of Technologies and Process Options for Sediments

The initial identification and screening of potentially applicable sediment technologies and process options is presented in Table 3-3. The results of the technology and process option screening is presented in Table 3-4. As indicated in Table 3-4, the sediments may be classified as a RCRA characteristic or listed hazardous waste. Lead concentrations of 861 mg/kg and 245 mg/kg at sediment locations 14 and 08 (Figure 1-10) could potentially fail the Toxicity Characteristic Leaching Procedure (TCLP) test (i.e., lead concentration in extraction fluid in excess of 5.0 mg/L constitutes TCLP failure), which would result in the material being classified as a RCRA characteristic waste for lead based on toxicity (D008 waste code). However, since lead concentrations in most of the sediment samples were less than 200 mg/kg, it is likely that the sediments would pass the TCLP test. With respect to RCRA listed waste classifications, the sediment may be considered a P37 waste, which is the waste code for dieldrin contained in discarded commercial chemical products, off-specification species, container residues, and spill residues thereof (40 CFR Part 261.33). However, since dieldrin detected in the sediments was most likely the result of past routine use of pesticides on Base, the dieldrin-contaminated sediments should not fall under the P37 category. For these reasons, disposal in an off-site secure solid waste landfill was selected as a representative process option for the contaminated sediments.

As also indicated in Table 3-4, incineration was not retained for further consideration in the FS in order to streamline the number of remedial alternatives and focus the evaluation on the most cost-effective remedies. Since incineration would not treat the inorganic contaminants, the incinerated material would still require landfill disposal. The concentrations of organic contaminants in the sediments, though higher than the ecological-based cleanup levels, are relatively low compared to contaminant levels often found at hazardous waste sites and are below the RCRA Land Disposal Restriction (LDR) treatment standards (40 CFR Part 268).

The following sediment remedial alternatives were developed using the retained sediment technologies and representative process options:

- Alternative SD-1: No Action
- Alternative SD-2A: Removal and Off-Site Disposal of Sediments Exceeding ER-L Cleanup Levels
- Alternative SD-2B: Removal and Off-Site Disposal of Sediments Exceeding ER-M Cleanup Levels

Alternatives SD-2A and SD-2B were developed based on the ER-L and ER-M ecological-based cleanup levels presented in Section 2.3.2. The alternatives are essentially identical except for the degree of cleanup achieved (i.e., volume of contaminated material removed and disposed). In order to avoid duplication in the FS, institutional controls for sediments have been included under the institutional control alternative for soil (Alternative SO-2). The above alternatives are described and evaluated in Section 6.0.

3.3 Identification and Screening of Technologies and Process Options for Groundwater

The initial identification and screening of potentially applicable groundwater technologies and process options is presented in Table 3-5. The results of the technology and process option screening and is presented in Table 3-6.

As indicated in Table 3-6, air stripping and UV/peroxide oxidation were eliminated as representative process options for treatment of contaminated groundwater. Chlorobenzene, the primary contaminant of concern, can be removed through air stripping, but would require higher air-to-water ratios than other VOCs, such as trichloroethene. In addition, an air stripper would be more subject to iron fouling than would activated carbon, and may, therefore, require additional pretreatment equipment for dissolved iron removal. UV/peroxide oxidation may also be a feasible technology, but treatability testing may be required to determine an accurate cost estimate for this technology. Carbon adsorption was selected as the representative process option since it is well-proven, economical for low flow rates, and relatively straightforward to install and operate.

The following groundwater remedial alternatives were developed using the retained groundwater technologies and representative process options:

- Alternative GW-1: No Action
- Alternative GW-2: Institutional Controls with Monitoring
- Alternative GW-3: Groundwater Extraction/Treatment with Institutional Controls and Monitoring

The above alternatives are described and evaluated in Section 5.0. As discussed in Section 5.0, monitoring of the surface water and sediments has been included under Alternatives GW-2 and GW-3 since this activity would most likely be performed in conjunction with groundwater monitoring efforts.

TABLE 3-1

INITIAL SCREENING OF SOIL REMEDIAL TECHNOLOGIES
CD LANDFILL SITE
NAVAL BASE NORFOLK, VIRGINIA

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
No Action	None	Not Applicable	No Action - Contaminated materials remain in-place	Required for consideration by NCP.
Institutional Actions[1]	Access Restriction	Fencing	Erect fencing to reduce site access.	Current fencing restricts access. Additional fencing potentially applicable.
	Land Use Controls	Base Master Plan	Use of Base Master Plan to restrict current and future land use on base.	Potentially applicable.
	Legal Restrictions	Deed Restrictions	Use of deed restrictions and Base mapping to restrict future site uses (e.g., Real Estate mapping).	Potentially applicable.
Containment Actions	Capping	Clay Cap	Clay cap to prevent contact with soil and restrict infiltration of precipitation.	Potentially applicable as a low-permeability cap.
		Synthetic Membrane	Synthetic membrane cap to prevent contact with soil and restrict infiltration of precipitation.	Potentially applicable as a low-permeability cap.
		Composite Cap	Combination clay/synthetic membrane cap to prevent contact with soil and restrict infiltration of precipitation.	Potentially applicable as a low-permeability cap.
		Asphalt Cap	Asphalt cover to prevent contact with soil and restrict infiltration of precipitation.	Potentially applicable as a low-permeability cap.
		Soil Cover	Soil layer to minimize contact with soil.	Potentially not applicable as a permeable cap.

(1) Includes drainage ditch areas.

TABLE 3-2

SUMMARY OF SOIL TECHNOLOGY EVALUATION AND SCREENING CD LANDFILL SITE NAVAL BASE NORFOLK, VIRGINIA

General Response Action	Remedial Technology	Process Option	Screening Comments
No Action	None	Not Applicable	Retain for further consideration.
Institutional Actions[1]	Access Restriction	Fencing	Retain for further consideration.
	Land Use Controls	Base Master Plan	Retain for further consideration.
		Deed Restrictions	Retain for further consideration.
Containment Actions	Capping	Clay Cap	Eliminate as a representative process option for a low permeability cap in FS. Retain for possible design consideration (if alternative is selected).
		Synthetic Membrane	Eliminate as a representative process option for a low permeability cap in FS. Retain for possible design consideration (if alternative is selected).
		Composite Cap	Retain as a representative process option for low permeability cap.
		Asphalt Cap	Eliminate as a representative process option for a low permeability cap in FS. Retain for possible design consideration (if alternative is selected).
		Soil Cover	Retain for further consideration.

[1] Includes drainage ditch areas.

TABLE 3-3

INITIAL SCREENING OF SEDIMENT REMEDIAL TECHNOLOGIES
CD LANDFILL SITE
NAVAL BASE NORFOLK, VIRGINIA

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
No Action	None	Not Applicable	No Action	Required for consideration by NCP.
Containment Actions	Capping	Concrete Culvert	Installation of concrete culverts and piping along northern and southern drainage ditches to contain contaminated sediments.	Not implementable due to high water table conditions. Eliminate from further consideration.
		Riprap Lining	Installation of riprap along northern and southern drainage ditches to contain contaminated sediments.	Riprap installation would require extensive sediment excavation for proper placement and stormwater flow. Sediment excavation and disposal addressed under separate Response Action. Eliminate from further consideration.
Excavation/Off-Site Disposal	Off-Site Disposal	RCRA Hazardous Waste Landfill	Excavated sediments are transported to a RCRA-permitted facility for disposal.	Potentially applicable.
		Solid Waste Landfill	Excavated sediments are transported to a permitted solid waste landfill, such as a sanitary landfill, for disposal.	Potentially Applicable.
Excavation/Off-Site Treatment	Stabilization/Fixation	Cement Based Stabilization	Involves sealing wastes in a matrix using Portland Cement.	Typically used for metals. Not well-proven for organic contaminants of concern. Eliminate from further consideration.
		Silicate-Based Stabilization	Involves microencapsulating wastes by sealing them using siliceous materials.	Typically used for metals. Not well-proven for organic contaminants of concern. Eliminate from further consideration.
	Thermal Treatment	Soil Recycling - Asphalt Incorporation	Involves the incorporation of contaminated soils into hot asphalt mixes as a partial substitute for stone aggregate.	Typically used for fuel-contaminated soils. Not applicable to contaminants of concern. Eliminate from further consideration.
		Soil Recycling - Cement Production	Contaminated sediments are introduced as raw materials into the cement production process.	Typically used for fuel-contaminated soils. Not applicable to contaminants of concern. Eliminate from further consideration.

TABLE 3-3 (Continued)

INITIAL SCREENING OF SEDIMENT REMEDIAL TECHNOLOGIES
CD LANDFILL SITE
NAVAL BASE NORFOLK, VIRGINIA

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Excavation/Off-Site Treatment (Continued)	Thermal Treatment (Continued)	Soil Recycling - Brick Manufacturing	Contaminated sediments is blended with clay and shale, raw materials used in the brick manufacturing process.	Typically used for fuel-contaminated soils. Not applicable to contaminants of concern. Eliminate from further consideration.
		Incineration	Volatilization and oxidation of organics via contact with high temperatures and oxygen. Common units include rotary kiln and fluidized/circulating bed reactors.	Potentially applicable.
	Biological	Bioremediation Cell Facility	Contaminated sediments are bioremediated using a land treatment technique.	Not well-proven for organic contaminants of concern. Eliminate from further consideration.

TABLE 3-4

SUMMARY OF SEDIMENT TECHNOLOGY EVALUATION AND SCREENING
CD LANDFILL SITE
NAVAL BASE NORFOLK, VIRGINIA

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
No Action	None	Not Applicable	No Action	Required for consideration by NCP.
Excavation/Off-Site Disposal	Off-Site Disposal	RCRA Hazardous Waste Landfill	Excavated sediments are transported to a RCRA-permitted facility for disposal.	Eliminate as a representative process option for the FS. Retain for possible design consideration (if alternative is selected) if sediment is determined to be a RCRA characteristic and/or listed hazardous waste.
		Solid Waste Landfill	Excavated sediments are transported to a permitted solid waste landfill, such as a sanitary landfill, for disposal.	Retain as a representative process option for the FS.
Excavation/Off-Site Treatment	Thermal Treatment	Incineration	Volatilization and oxidation of organics via contact with high temperatures and oxygen. Common units include rotary kiln and fluidized/circulating bed reactors.	Although incineration will effectively treat organics, it will not treat inorganics, which will then require landfill disposal. Incineration also will not achieve a significant volume reduction, is not required to meet RCRA Land Disposal Restriction requirements (40 CFR Part 268), and is significantly more costly to implement than disposal in a secure landfill. Therefore, incineration will be eliminated from further consideration.

TABLE 3-5

INITIAL SCREENING OF GROUNDWATER REMEDIAL TECHNOLOGIES
CD LANDFILL SITE
NAVAL BASE NORFOLK, VIRGINIA

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
No Action	Intrinsic Bioremediation	Aerobic/Anaerobic Treatment	Use of indigenous (natural) microorganisms (i.e., bacteria) to biodegrade contaminants without the addition of election acceptors (e.g., oxygen) or nutrients.	Incorporate into No Action alternative.
Institutional Controls	Monitoring[(1)]	Monitoring	Ongoing monitoring of wells and surface waters.	Potentially applicable.
	Aquifer Use Controls	Base Master Plan	Use of Base Master Plan to restrict future use of groundwater.	Potentially applicable.
		Deed Restrictions	Property deed would include restrictions on use of groundwater, denial of well permits, and acquisition of water rights.	Potentially applicable.
	Public Education	Meetings, written notices	Meetings and written notices to inform public of potential health risks associated with groundwater usage.	Potentially applicable.
Containment Actions	Vertical Barriers	Grout Curtain	Pressure injection of grout in a regular pattern of drilled holes to contain contamination.	No continuous confining layer under the site to which the wall should adjoin. Eliminate from further consideration.
		Slurry Wall	Trench around areas of contamination. The trench is filled with a soil bentonite slurry to limit migration of contaminants.	No continuous confining layer under the site to which the wall should adjoin. Eliminate from further consideration.
		Sheet Piling	Interlocking sheet pilings installed via drop hammer around areas of contamination.	No continuous confining layer under the site to which the wall should adjoin. Eliminate from further consideration.
	Extraction	Extraction Wells	Series of wells used to extract contaminated groundwater.	Applicable
		Dual-Phase Vacuum Extraction	Extraction of a two-phase air-water stream under high vacuum using wells screened above and below the water table.	Applicable for sites with low permeability and hydraulic conductivity. Not applicable to site hydrogeology. Eliminate from further consideration.

TABLE 3-5 (Continued)

INITIAL SCREENING OF GROUNDWATER REMEDIAL TECHNOLOGIES
CD LANDFILL SITE
NAVAL BASE NORFOLK, VIRGINIA

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Containment Actions (Continued)	Subsurface Drains	Interceptor Trenches	Perforated pipe installed in trenches backfilled with porous medium to collect contaminated groundwater.	More difficult to implement and control than extraction wells. Eliminate from further consideration.
Collection Actions	Extraction	Extraction Wells	Series of wells used to extract contaminated groundwater at a pumping rate to sufficiently contain contaminant migration.	Applicable
		Dual-Phase Vacuum Extraction	Extraction of a two-phase air-water stream under high vacuum using wells screened above and below the water table.	Applicable for sites with low permeability and hydraulic conductivity. Not applicable to site hydrogeology. Eliminate from further consideration.
	Subsurface Drains	Interceptor Trenches	Perforated pipe installed in trenches backfilled with a porous medium (e.g., gravel) to collect contaminated groundwater.	More difficult to implement and control than extraction wells. Eliminate from further consideration.
Treatment Actions	Biological Treatment	Aerobic (e.g., biotower, biofilter)	Degradation of organics using microorganisms in an oxygen environment.	Not well-proven for chlorobenzenes. Other effective, low-cost options are available. Eliminate from further consideration.
		Anaerobic (e.g., bioreactor)	Degradation of organics using microorganisms in the absence of oxygen.	Not well-proven of chlorobenzenes. Other effective, low-cost options are available. Eliminate from further consideration.
	Physical/Chemical Treatment	Air Stripping	Mixing large volumes of air with water in a packed column or shallow tray unit to promote transfer of VOCs to air. Applicable to volatile organics.	Potentially applicable
		Steam Stripping	Mixing large volumes of steam with water in a packed column to promote transfer of VOCs to air. Applicable to volatile organics.	Other effective, low-cost options are available. Eliminate from further consideration.

TABLE 3-5 (Continued)

INITIAL SCREENING OF GROUNDWATER REMEDIAL TECHNOLOGIES
CD LANDFILL SITE
NAVAL BASE NORFOLK, VIRGINIA

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Treatment Actions (Continued)	Physical/Chemical Treatment (Continued)	Carbon Adsorption	Adsorption of contaminants onto activated carbon by passing water through carbon column. Applicable to a wide range of organics.	Applicable
		Reverse Osmosis	Using high pressure to force water through a membrane leaving contaminants behind. Applicable to dissolved solids and high molecular weight organics.	Not applicable to contaminants of concern.
		Ion Exchange	Contaminated water is passed through a resin bed where ions are exchanged between resin and water. Applicable for inorganic contaminants (metals).	Not applicable to contaminants of concern.
		Chemical Reduction	Addition of a reducing agent to lower the oxidation state of a substance to reduce toxicity/solubility.	Not applicable to contaminants of concern.
		Chemical Oxidation	Addition of an oxidizing agent (e.g., UV radiation and hydrogen peroxide) to raise the oxidation state of a substance. Applicable to organics and certain metals.	Potentially applicable for destruction of organic contaminants and as a pretreatment step for metals.
		Electrochemical Ion Generation	Electrical currents used to put ferrous and hydroxyl ions into solution for subsequent removal via precipitation. Applicable to metals removal.	Not applicable as a pretreatment step.
		Neutralization	Addition of an acid or base to a waste in order to adjust its pH. applicable to acidic or basic waste streams.	Potentially applicable as a pre- and post-treatment step.
		Precipitation	Materials in solution are transferred into a solid phase for removal. Applicable to particulates and metals.	Potentially applicable as a pretreatment step.
		Oil/Water Separation	Materials in solution are transferred into a separate phase for removal. Applicable to petroleum hydrocarbons.	Not necessary for the contaminants of concern. No free phase product detected at the sites.

TABLE 3-5 (Continued)

INITIAL SCREENING OF GROUNDWATER REMEDIAL TECHNOLOGIES
CD LANDFILL SITE
NAVAL BASE NORFOLK, VIRGINIA

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Treatment Actions (Continued)	Physical/Chemical Treatment (Continued)	Filtration	Removal of suspended solids from solution by forcing the liquid through a porous medium. Applicable to suspended solids.	Potentially applicable as a pretreatment step.
		Flocculation	Small, unsettleable particles suspended in a liquid medium are made to agglomerate into larger particles by the addition of flocculating agents. Applicable to particulates and inorganics.	Potentially applicable as a pretreatment step.
		Sedimentation	Removal of suspended solids in an aqueous waste stream via gravity separation. Applicable to suspended solids.	Potentially applicable as a pretreatment step.
	Off-site Treatment	Municipal Wastewater Treatment Plant	Extracted groundwater discharged to city facility for treatment.	Not permitted for long-term groundwater remediation. Eliminate from further consideration.
		Hazardous Waste Treatment Facility	Extracted groundwater discharged to licensed facility for treatment and disposal.	Not implementable due to large volume of groundwater. Eliminate from further consideration.
	In-Situ Treatment	Biodegradation (e.g., Biosparging)	System of introducing nutrients and oxygen to groundwater for the stimulation or augmentation of microbial activity to degrade contamination.	Not well-proven for chlorobenzenes. May not prevent discharge of contaminated groundwater to drainage ditches. Eliminate from further consideration.
		Air Sparging	The injection of air under pressure in groundwater to remove VOCs via volatilization. Air bubbles migrate into the vadose zone where they can be extracted and treated by other methods. Introduction of air also may promote degradation of contaminants through biological transformation.	Marginal effectiveness for chlorobenzenes due to low volatility. May not prevent discharge of contaminated groundwater to drainage ditches. Eliminate from further consideration.

TABLE 3-5 (Continued)

INITIAL SCREENING OF GROUNDWATER REMEDIAL TECHNOLOGIES
CD LANDFILL SITE
NAVAL BASE NORFOLK, VIRGINIA

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Treatment Actions (Continued)	In-Situ Treatment (Continued)	In-Well Aeration (i.e., vacuum vaporizer well, in-situ air stripping)	Process of inducing air into a well by applying a vacuum. Results in an in-well airlift pump effect that serves to strip volatiles from groundwater inside the well and establish a groundwater circulation cell.	Marginal effectiveness for chlorobenzenes due to low volatility. May not prevent discharge of contaminated groundwater to drainage ditches. Eliminate from further consideration.
Discharge Actions	On-Site Discharge	Reinjection ● Injection Wells ● Infiltration Galleries	Treated water reinjection into the site aquifer via use of shallow infiltration galleries (trenches) or injection wells.	More costly and difficult to implement than surface water discharge. Eliminate from further consideration.
		Surface Water	Treated water discharged to a local surface water, such as a stream or river.	Applicable

(1) Includes surface water.

TABLE 3-6

SUMMARY OF GROUNDWATER TECHNOLOGY EVALUATION AND SCREENING
CD LANDFILL SITE
NAVAL BASE NORFOLK, VIRGINIA

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
No Action	Intrinsic Bioremediation	Aerobic/Anaerobic Treatment	Use of indigenous (natural) microorganisms (i.e., bacteria) to biodegrade contaminants without the addition of election acceptors (e.g., oxygen) or nutrients.	Retain for further consideration.
Institutional Controls	Monitoring[1]	Monitoring	Ongoing monitoring of wells and surface waters.	Retain for further consideration.
	Aquifer Use Controls	Base Master Plan	Use of Base Master Plan to restrict future use of groundwater.	Retain for further consideration.
		Deed Restrictions	Property deed would include restrictions on use of groundwater, denial of well permits, and acquisition of water rights.	Retain for further consideration.
	Public Education	Meetings, written notices	Meetings and written notices to inform public of potential health risks associated with groundwater usage.	Retain for further consideration.
Containment Actions	Extraction	Extraction Wells	Series of wells used to extract contaminated groundwater.	Retain for further consideration.
Collection Actions	Extraction	Extraction Wells	Series of wells used to extract contaminated groundwater at a pumping rate to sufficiently contain contaminant migration.	Retain for further consideration.
Treatment Actions	Physical/Chemical Treatment	Air Stripping	Mixing large volumes of air with water in a packed column or shallow tray unit to promote transfer of VOCs to air. Applicable to volatile organics.	Eliminate as a representative process option for the FS due to potential low removal efficiency for chlorobenzenes. Retain for possible design consideration (if alternative is selected).

TABLE 3-6 (Continued)

SUMMARY OF GROUNDWATER TECHNOLOGY EVALUATION AND SCREENING
CD LANDFILL SITE
NAVAL BASE NORFOLK, VIRGINIA

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Treatment Actions (Continued)	Physical/Chemical Treatment (Continued)	Carbon Adsorption	Adsorption of contaminants onto activated carbon by passing water through carbon column. Applicable to a wide range of organics.	Retain as a representative process option for the FS.
		Chemical Oxidation	Addition of an oxidizing agent (e.g., UV radiation and hydrogen peroxide) to raise the oxidation state of a substance. Applicable to organics and certain metals.	Eliminate UV/peroxide oxidation for chlorobenzenes as a representative process option for the FS since it is an innovative technology requiring treatability testing. Eliminate oxidation as a representative process option for the FS for metals pretreatment (iron and manganese). Retain both for possible design consideration (if alternative is selected).
		Neutralization	Addition of an acid or base to a waste in order to adjust its pH. applicable to acidic or basic waste streams.	May be required to maintain pH in neutral range. Retain for further consideration.
		Precipitation	Materials in solution are transferred into a solid phase for removal. Applicable to particulates and metals.	Eliminate as a representative process option for the FS. Retain for possible design consideration (if alternative is selected).
		Filtration	Removal of suspended solids from solution by forcing the liquid through a porous medium. Applicable to suspended solids.	Potentially applicable as a pretreatment step. Retain as a representative process option.
		Flocculation	Small, unsettleable particles suspended in a liquid medium are made to agglomerate into larger particles by the addition of flocculating agents. Applicable to particulates and inorganics.	Eliminate as a representative process option for the FS. Retain for possible design consideration (if alternative is selected).
		Sedimentation	Removal of suspended solids in an aqueous waste stream via gravity separation. Applicable to suspended solids.	Retain as a representative process option.

TABLE 3-6 (Continued)

SUMMARY OF GROUNDWATER TECHNOLOGY EVALUATION AND SCREENING
CD LANDFILL SITE
NAVAL BASE NORFOLK, VIRGINIA

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Discharge Actions	On-Site Discharge	Surface Water	Treated water discharged to a local surface water (drainage ditch).	Retain for further consideration.

(1) Includes surface water.

4.0 DETAILED ANALYSIS OF SOIL REMEDIAL ALTERNATIVES

In this section, the general response actions, remedial technologies, and process options retained from the screening and evaluation step in Section 3.0 are combined to form soil remedial action alternatives. The following soil alternatives have been developed for the CD Landfill Site:

- Alternative SO-1: No Action
- Alternative SO-2: Institutional Controls
- Alternative SO-3: Soil Cap with Institutional Controls
- Alternative SO-4: Composite Cap with Institutional Controls

In this section, a detailed analysis and comparison of remedial alternatives developed for soils are presented in Sections 4.1 through 4.5. Typically in a feasibility study, an initial group of remedial alternatives is developed that undergoes an initial screening based on effectiveness, implementability, and cost. The purpose of this screening is to reduce the number of alternatives that are subsequently evaluated in the detailed analysis section. However, since only a limited number of alternatives have been developed for the soils at the CD Landfill Site, the initial screening step was not performed.

Detailed analysis of each alternative will be conducted in accordance with the "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (EPA, 1988b) and the NCP, including the February 1990 revisions. In conformance with the NCP, seven of the following nine criteria will be used for the detailed analysis:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume
- Short-term effectiveness
- Implementability

- Cost
- State acceptance (not evaluated at this time)
- Community acceptance (not evaluated at this time)

State acceptance and community acceptance will be evaluated in the Decision Document by addressing comments received after the FS and Proposed Remedial Action Plan (PRAP) have been reviewed by the Restoration Advisory Board (RAB), which includes participants from the Virginia Department of Environmental Quality and the public.

Overall Protection of Human Health and the Environment: The primary requirement is that remedial actions are protective of human health and the environment. A remedy is protective if it adequately eliminates, reduces, or controls all current and potential site risks posed through each exposure pathway at the site. A site where, after the remedy is implemented, hazardous substances remain without engineering or institutional controls, must allow for unrestricted use and unlimited exposure for human and environmental receptors. Alternatively, adequate engineering controls, institutional controls, or some combination of the two must be implemented to control exposure and thereby ensure reliable protection over time. In addition, implementation of a remedy cannot result in unacceptable short-term risks or cross-media impacts on human health and the environment.

Compliance with Applicable or Relevant and Appropriate Requirements (ARARs): Compliance with ARARs is one of the statutory requirements for remedy selection. Alternatives are developed and refined throughout the FS process to ensure that they will meet all of the respective ARARs or that there is a good rationale for waiving an ARAR. During the detailed analysis, information on federal and state action-specific ARARs will be assembled along with previously identified contaminant-specific and location-specific ARARs. Alternatives will be refined to ensure compliance with these requirements.

Long-term Effectiveness and Permanence: This criterion reflects CERCLA's emphasis on implementing remedies that will ensure protection of human health and the environment in the future, as well as in the near term. In evaluating alternatives for their long-term effectiveness and the degree of permanence they afford, the analysis will focus on the residual risks present at the site after the completion of the remedial action. The analysis will include consideration of the following:

- Degree of threat posed by the hazardous substances remaining at the site.

- Adequacy of any controls (e.g., engineering and institutional controls) used to manage the hazardous substances remaining at the site.

- Reliability of those controls.

- Potential impacts on human health and the environment, should the remedy fail, based on assumptions included in the reasonable maximum exposure scenario.

Reduction of Toxicity, Mobility, or Volume (TMV) through Treatment: This criterion addresses the statutory preference for remedies that employ treatment as a principal element by ensuring that the relative performance of the various treatment alternatives in reducing the toxicity, mobility, or volume will be assessed. Specifically, the analysis will examine the magnitude, significance, and irreversibility of reductions.

Short-term Effectiveness: This criterion examines the short-term impacts of the alternative (i.e., impacts of the implementation) on the neighboring community, workers, or surrounding environment. This includes potential threats to human health and the environment associated with the excavation, treatment, and transportation of hazardous substances. The potential cross-media impacts of the remedy and the time to achieve protection of human health and the environment will also be analyzed.

Implementability: Implementability considerations include the technical and administrative feasibility of the alternatives, as well as the availability of goods and services (e.g., treatment, storage, or disposal capacity) on which the viability of the alternative depends. Implementability considerations often affect the timing of various remedial alternatives (e.g., limitations on the season in which the remedy can be implemented, the number and complexity of material handling steps, and the need to secure technical services). On-site activities must comply with the substantive portions of applicable permitting regulations.

Cost: Cost includes all capital costs and annual operation and maintenance costs incurred over the life of the project. The focus during the detailed analysis is on the present worth of these costs.

Costs are used to select the most cost-effective alternative that will achieve the remedial action objectives.

State Acceptance: This criterion, which is an ongoing concern throughout the remedial process, reflects the statutory requirement to provide for substantial and meaningful state involvement. State comments will be addressed during the development of the PRAP and Decision Document, as appropriate.

Community Acceptance: This criterion refers to the community's comments on the remedial alternatives under consideration, where "community" is broadly defined to include all interested parties. These comments are taken into account throughout the FS process. However, only preliminary assessment of community acceptance can be conducted during the development of the FS, since formal public comment will not be received until after the public comment period for the PRAP is held.

4.1 Alternative SO-1: No Action

Description: Evaluation of the No Action Alternative is required by the NCP to provide a baseline comparison for other remediation alternatives. Under the No Action Alternative, no remedial actions would be performed at the CD Landfill Site.

Overall Protection: Results of the baseline risk assessment indicate that no unacceptable adverse human health effects would be expected from exposure (via ingestion, inhalation, and dermal contact) to surface soil under the current and future land use of the area for military personnel, child and adult trespassers, future civilian and construction workers, and child and adult residents. The estimated incremental lifetime cancer risk (ILCR) values were all within the acceptable range of 1.0×10^{-4} to 1.0×10^{-6} under CERCLA. With respect to potential noncarcinogenic health effects, the estimated hazard index (HI) for each receptor and exposure scenario was less than the acceptable level of 1.0 under CERCLA, except for the child resident scenario for which the HI of 1.2 only slightly exceeded 1.0.

The risk assessment also indicates that no unacceptable adverse human health effects would be expected from exposure to subsurface soils under a future use scenario for remedial construction workers. The risk assessment indicates that adverse human health effects may be expected from exposure to subsurface soils for both the future adult and child resident, as the ILCRs were calculated at 3.1×10^{-4} and 1.9×10^{-4}, respectively. Similarly, the HIs calculated for exposure to subsurface soils for the adult and child resident scenarios are 4.8 and 20, respectively, which exceed the acceptable HI of 1.0 under CERCLA. An HI of 5.4 was calculated for the adult construction worker, which also exceeds the acceptable HI of 1.0 under CERCLA.

This alternative would not provide any additional protection against exposure to potential contamination than that currently offered by the existing soil and vegetative cover, as well as the existing fencing which does not encompass the entire landfill. However, the only area of the landfill which is currently accessible is the extreme eastern portion of the site, adjacent to the NAS glide path. Since access to the NAS itself is restricted, the CD Landfill is currently not accessible to the general public.

Potential contamination present in the landfill could provide a source of shallow and deep groundwater contamination, particularly in areas where the clay confining layer is not present. However, as discussed in Section 2.0, the extent of contamination in the shallow groundwater (water table) aquifer appears to be limited (primarily to well MW-05A), and the Yorktown Aquifer appears to be only marginally impacted by the site (i.e., no contaminants were detected above primary MCLs). Therefore, the actual threat of leaching of contaminants from soils to groundwater at the site may be minimal.

The results of the ecological risk assessment indicated that several inorganic and a few organic contaminants in the surface soil exceeded their respective surface soil screening levels (SSSLs), suggesting that the site may pose a risk to terrestrial ecological receptors. However, since the SSSLs are not based on site specific studies or conditions, and are typically derived from very conservative exposure assumptions, exceedances of the SSSLs do not necessarily indicate that the site poses an unacceptable ecological risk. In general, the landfill does not represent a high quality habitat or sensitive environment. No rare or endangered species have been observed on site.

Compliance with ARARs: State and federal contaminant-specific ARARs are not available for soils. There are no location- or action-specific ARARs associated with this alternative.

Long-term Effectiveness and Permanence: There would be no remedial action under this alternative. The potential human health risks would remain the same as noted in the baseline risk assessment. However, based on the baseline risk assessment, there are no unacceptable risks under the current land use. The site is currently not used for residential purposes, and there are no plans to convert the area to residential use. However, there is currently no official land use designation for the site or any specific restrictions or warnings associated with invasive construction activities.

This alternative is not a permanent solution in the sense that it provides no additional actions for preventing exposure to potential contaminants within the landfill (remedial action objective 1 for soils) or for minimizing leaching of potential contaminants from soil to groundwater (remedial action objective 2 for soils). However, as previously indicated, the threat of contaminant leaching to groundwater may be minimal. This alternative also does not prevent ecological exposure to surface soils (remedial action objective 3 for soils). However, as previously noted, the landfill does not represent a high quality habitat or sensitive environment.

Reduction of Toxicity, Mobility, or Volume: This alternative would not reduce the toxicity, mobility, or volume of potential contaminants in the landfill through active treatment. However, there may be a reduction in toxicity and volume of contaminants in the long-term through natural processes such as biodegradation, volatilization and dispersion. As previously noted, groundwater sampling results suggest that the actual degree of contaminant leaching to groundwater may be minimal.

Short-term Effectiveness: This alternative does not involve remedial actions that would pose a risk to human health or the environment during implementation.

Implementability: The No Action Alternative would be both technically and administratively straight forward to implement since there are no remedial activities associated with this alternative.

Cost: There are no costs associated with this alternative.

4.2 Alternative SO-2: Institutional Controls

Description: Under this alternative, the existing fencing and gates at the site, which surround the majority of the landfill, would be maintained to limit access to the landfill. In addition, warning signs would be installed at each gate entrance to indicate that wastes are buried at the site. The existing soil cover and vegetation would also be periodically inspected and maintained, as necessary, to limit surface water infiltration and minimize potential erosion.

The site is currently not used for residential purposes, and there are no plans to close the Base or to convert the area to residential use. However, there is currently no official land use designation for the site. A Master Plan for the Base is currently under development. Under this alternative, the site would be given a land use category that would prohibit residential use of the area as well as restrict invasive construction activities. In addition, deed restrictions would be implemented, which would involve adding these land use restrictions to the appropriate Base real estate maps. These actions would also apply to the drainage ditch sediments located on and adjacent to the landfill and within the fenced area.

Overall Protection: Results of the baseline risk assessment indicate that no unacceptable adverse human health effects would be expected from exposure (via ingestion, inhalation, and dermal contact) to surface soil under the current and future land use of the area for military personnel, child and adult trespassers, future civilian and construction workers, child and adult residents. The estimated ILCR values were all within the acceptable range of 1.0×10^{-4} to 1.0×10^{-6} under CERCLA. With respect to potential noncarcinogenic health effects, the estimated HI for each receptor and exposure scenario was less than the acceptable level of 1.0 under CERCLA, except for the child resident scenario for which the HI of 1.2 only slightly exceeded 1.0.

The risk assessment also indicates that no unacceptable adverse human health effects would be expected from exposure to subsurface soils under a future use scenario for remedial construction workers. The risk assessment indicates that adverse human health effects may be expected from exposure to subsurface soils for both the future adult and child resident, as the ILCRs were calculated at 3.1×10^{-4} and 1.9×10^{-4}, respectively. Similarly, the HIs calculated for exposure to subsurface soils for the adult and child resident scenarios are 4.8 and 20, respectively, which exceed the acceptable HI of 1.0 under CERCLA. An HI of 5.4 was calculated for the adult construction worker, which also exceeds the acceptable HI of 1.0 under CERCLA.

This alternative would provide protection to human health through maintenance of the existing fencing and soil cover, installation of warning signs, and incorporation of land use restrictions in the Base Master Plan and real estate mapping. These actions would significantly reduce the chance of exposure to potential contaminants within the landfill as well as the surface water and sediments located within the fenced area.

Potential contamination present in the landfill could provide a source of shallow and deep groundwater contamination, particularly in areas where the clay confining layer is not present. However, as discussed in Section 2.0, the extent of contamination in the shallow groundwater (water table) aquifer appears to be limited (primarily to well MW-05A), and the Yorktown Aquifer appears to be only marginally impacted by the site (i.e., no contaminants were detected above primary MCLs). Therefore, the actual threat of leaching of contaminants from soils to groundwater at the site may be minimal.

Compliance with ARARs: State and federal contaminant-specific ARARs are not available for soils. There are also no location specific ARARs associated with this alternative. The only action-specific ARARs and TBCs associated with this alternative are the Virginia solid and hazardous waste closure (i.e., capping) requirements as described below:

The closure requirements for construction/demolition debris landfills under the Virginia Solid Waste Regulations (VR 672-20-10, Part V, Section 5.2.E), which are TBC criteria for the unpermitted part of the landfill, require that the final cover system be designed in a manner that minimizes the need for further maintenance, and controls, minimizes, or eliminates the post-closure escape of uncontrolled leachate, surface runoff, decomposition gas migration, or waste decomposition products to the groundwater, surface water, or atmosphere. The existing landfill cover essentially complies with these requirements with the exception of leachate minimization. However, the amount of contaminated leachate production appears to be minimal, since groundwater contamination is generally limited to one monitoring well. Furthermore, the effectiveness of applying soil capping technology at the CD Landfill Site in accordance with the Virginia Solid

Waste Regulations (i.e., 18-inch soil cover with hydraulic conductivity no greater than 1×10^{-5} cm/sec) is questionable due to the lack of a liner system and high water table conditions.

The closure requirements for hazardous waste landfills under the Virginia Hazardous Waste Regulations (VR 672-10-1, Part X, Section 10.13.K), which are relevant and appropriate for the permitted part of the landfill, require that the final cover be designed and constructed to:

- Provide long-term minimization of migration of liquids through the closed landfill;
- Function with minimum maintenance;
- Promote drainage and minimize erosion and abrasion of the cover;
- Accommodate settling and subsidence so that the cover's integrity is maintained; and
- Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present.

The existing landfill cover essentially complies with these requirements with the exception of long-term minimization of migration of liquids through the closed landfill. However, as previously noted, the amount of contaminated leachate production appears to be minimal, and the effectiveness of applying capping technology at the CD Landfill Site is questionable due to site conditions.

Long-term Effectiveness and Permanence: Institutional controls would be effective in the long-term in restricting the landfill area to non-residential land uses, thereby reducing any health hazards posed by potential contamination in these areas. Thus, this alternative provides a permanent solution in the sense that it provides specific actions for preventing exposure to potential contaminants within the landfill (remedial action objective 1 for soils) as well as exposure to potential contaminants in the surface water and sediments located within the fenced area.

This alternative does not provide any actions for minimizing leaching of potential contaminants from soil to groundwater (remedial action objective 2). However, as previously indicated, the threat of contaminant leaching to groundwater may be minimal. This alternative also does not prevent ecological exposure to surface soils (remedial action objective 3 for soils). However, as previously noted, the landfill does not represent a high quality habitat or sensitive environment.

Reduction of Toxicity, Mobility, or Volume: This alternative would not reduce the toxicity, mobility, or volume of potential contaminants through active treatment. There may be a reduction in toxicity and volume of potential contaminants in the long-term through natural processes such as biodegradation, volatilization, and dispersion. As previously noted, groundwater sampling results suggest that the actual degree of contaminant leaching to groundwater may be minimal.

Short-term Effectiveness: Implementation of institutional controls would not pose a short-term risk to human health or the environment since no remedial actions would be implemented other than maintenance of the existing fencing and soil cover and administrative actions associated with land use restrictions.

Implementability: This alternative would be technically straight forward to implement. Periodic inspection and maintenance of the existing fencing and soil cover would be required.

Cost: The estimated costs of this alternative are as follows:

- Capital: $1,000
- Annual operation and maintenance: $4,400
- Net present worth (30-year): $69,000

Detailed cost estimate spreadsheets are provided in Appendix B.

4.3 Alternative SO-3: Soil Cap with Institutional Controls

Description: This alternative includes the placement of a one-foot-thick soil cap over the landfill. The soil cap would be installed over the eastern and western sections of the landfill as shown in Figure 4-1. The soil cap sections would encompass areas of approximately 18.4 acres and 3.2 acres, respectively. The existing Seabee Road would remain intact along with its right-of-way, which has been landscaped with trees and shrubs. The purpose of the cap would be to augment the existing cover system to provide additional protection to both human and ecological (i.e., terrestrial) receptors.

For costing purposes, it was assumed that the soil cap would be constructed of an eight inch soil fill and a four inch topsoil cover. A typical soil cap cross section is shown in Figure 4-2. The one foot of soil cover was determined to be appropriate for current conditions at the CD Landfill Site. The landfill surface is currently stabilized and well-vegetated, and the results of the baseline risk assessment indicate that there are no unacceptable risks to human health associated with the surface soils. Installation of a one-foot-thick soil cover will also pose fewer implementation difficulties than construction of a thicker cap with respect to disturbance of the existing mature trees and existing drainage patterns.

Prior to capping, the area would be cleared, grubbed, and stripped of vegetation consisting of small and poor quality trees. Mature trees, greater than approximately 8" in diameter, would remain. In areas containing trees to be removed, approximately 6 to 12 inches of soil may need to be excavated to remove the bulk of any tree roots. Herbicides may also be applied to prevent regrowth of vegetation following installation of the soil cap. Following stripping, the existing soil would be stabilized via mechanical compaction techniques to improve the physical properties of the soil and assist in maintaining the integrity of the soil cap. The soil would be regraded to provide a smooth surface and proper top and side slopes. Additional fill material may need to be imported to fill voids in some areas and provide for proper grades.

A venting system for decomposition gases may not be required because the landfill was used for disposal of non-putrescible wastes.

Surface water runoff would drain into the existing northern drainage ditch and the relocated southern drainage ditch which would be located around the perimeter of the soil cap. Access to the site would be accommodated via improved (gravel) roadways. A new portion of gravel roadway would be constructed to link the existing northern and the existing southern dirt roadways.

In addition to the soil cap, institutional controls and fencing, as described under Alternative SO-2 (Section 4.2), would also be implemented under this alternative to restrict access to the landfill and limit the site to non-residential use. Fencing for this alternative, however, would also incorporate the installation of additional fencing to completely enclose the site.

Overall Protection: Results of the baseline risk assessment indicate that no unacceptable adverse human health effects would be expected from exposure (via ingestion, inhalation, and dermal contact) to surface soil under the current and future land use of the area for military personnel, child and adult trespassers, future civilian and construction workers, and child and adult residents. The estimated ILCR values were all within the acceptable range of 1.0×10^{-4} to 1.0×10^{-6} under CERCLA. With respect to potential noncarcinogenic health effects, the estimated HI for each receptor and exposure scenario was less than the acceptable level of 1.0 under CERCLA, except for the child resident scenario for which the HI of 1.2 only slightly exceeded 1.0.

The risk assessment also indicates that no unacceptable adverse human health effects would be expected from exposure to subsurface soils under a future use scenario for remedial construction workers. The risk assessment indicates that adverse human health effects may be expected from exposure to subsurface soils for both the future adult and child resident, as the ILCRs were calculated at 3.1×10^{-4} and 1.9×10^{-4}, respectively. Similarly, the HIs calculated for exposure to subsurface soils for the adult and child resident scenarios are 4.8 and 20, respectively, which exceed the acceptable HI of 1.0 under CERCLA. An HI of 5.4 was calculated for the adult construction worker, which also exceeds the acceptable HI of 1.0 under CERCLA.

This alternative would provide protection to human health through installation and maintenance of the one-foot-thick soil cap, through maintenance of the existing and newly installed site fencing, installation of warning signs, and incorporation of land use restrictions in the Base Master Plan and real estate mapping. These actions would significantly reduce the chance of exposure to potential contaminants within the landfill.

Potential contamination present in the landfill could provide a source of shallow and deep groundwater contamination, particularly in areas where the clay confining layer is not present. The soil cap may slightly reduce the amount of contaminant leaching to groundwater by reducing the amount of infiltration through the fill materials. It should be noted that the extent of contamination in the shallow groundwater (water table) aquifer appears to be limited (primarily to well MW-05A), and the Yorktown Aquifer appears to be only marginally impacted by the site (i.e., no contaminants were detected above primary MCLs). Therefore, the actual threat of leaching of contaminants from soils to groundwater at the site may be minimal.

The results of the ecological risk assessment indicated that several inorganic and a few organic contaminants in the surface soil exceeded their respective surface soil screening levels (SSSLs), suggesting that the site may pose a risk to terrestrial ecological receptors. Installation of the soil cap would significantly reduce this risk covering contaminated areas with clean soil.

Compliance with ARARs: State and federal contaminant-specific ARARs are not available for soils. The only locaiton-specific ARARs associated with this alternative deal with the protection of floodplains (Executive Order 11988) and the protection of wetlands (Executive Order 11990 and Code of Virginia - Section 62.1-13.1 and VR 450-01-0051). During installation of the one-foot-thick soil cap, care must be taken to minimize the destruction, loss or degradation of existing wetlands during regrading and drainage ditch relocation activities. The major action-specific ARARs and TBCs associated with this alternative are the Virginia solid and hazardous waste closure (i.e., capping) requirements as described below:

The closure requirements for construction/demolition debris landfills under the Virginia Solid Waste Regulations (VR 672-20-10, Part V, Section 5.2.E), which are TBC criteria for the unpermitted part of the landfill, require that the final cover system be designed in a manner that minimizes the need for further maintenance, and controls, minimizes, or eliminates the post-closure escape of uncontrolled leachate, surface runoff, decomposition gas migration, or waste decomposition products to the groundwater, surface water, or atmosphere. The existing landfill cover essentially complies with these requirements with the exception of leachate minimization. The new soil cover would be designed and installed to improve the degree of compliance with these requirements. The new soil cover may slightly decrease the amount of leachate generation. However, the amount of contaminated leachate production appears to be minimal, since groundwater contamination is generally limited to one monitoring well. Furthermore, the effectiveness of applying soil capping technology at the CD Landfill Site in accordance with the Virginia Solid Waste Regulations (i.e., 18-inch soil cover with hydraulic conductivity no greater than 1×10^{-5} cm/sec) is questionable due to the lack of a liner system and high water table conditions.

The closure requirements for hazardous waste landfills under the Virginia Hazardous Waste Regulations (VR 672-10-1, Part X, Section 10.13.K), which are relevant and appropriate for the permitted part of the landfill, require that the final cover be designed and constructed to:

- Provide long-term minimization of migration of liquids through the closed landfill;
- Function with minimum maintenance;
- Promote drainage and minimize erosion and abrasion of the cover;
- Accommodate settling and subsidence so that the cover's integrity is maintained; and
- Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present.

The existing landfill cover essentially complies with these requirements with the exception of long-term minimization of migration of liquids through the closed landfill. The new soil cover would be designed and installed to comply with these requirements, again, with the exception of long-term minimization of migration of liquids through the closed landfill. However, as previously noted, the amount of contaminated leachate production appears to be minimal, and the effectiveness of applying capping technology at the CD Landfill Site is questionable due to site conditions.

Long-term Effectiveness and Permanence: Institutional controls would be effective in the long-term in restricting the landfill area to non-residential land uses, thereby reducing any health hazards posed by potential contamination in these areas. The soil cap would also provide additional protection by improving the buffer between the surface and waste materials. Thus, this alternative provides a permanent solution in the sense that it provides specific actions for preventing exposure to potential contaminants within the landfill (remedial action objective 1 for soils) as well as contaminants within the surface water and sediments located within the fenced area.

Installation of the soil cap may slightly reduce leaching of potential contaminants from soil to groundwater (remedial action objective 2 for soils). However, as previously indicated, the threat of contaminant leaching to groundwater may be minimal.

Installation of the soil cap, as well as complete enclosure (via fencing) of the site, would minimize direct ecological exposure to surface soils (remedial action objective 3 for soils).

Reduction of Toxicity, Mobility, or Volume: This alternative would not reduce the toxicity, mobility, or volume of potential contaminants through active treatment. There may be a reduction in toxicity and volume of potential organic contaminants in the long-term through natural processes such as biodegradation and volatilization. Installation of the soil cap may help to reduce the mobility of potential contaminants in the soil; however, as previously noted, the degree of reduction may be marginal because of the absence of a confining layer and a very shallow groundwater depth.

Short-term Effectiveness: Construction of the soil cap would require clearing, grubbing, and regrading activities that would disturb some of the landfill contents and potentially pose a risk to workers, nearby Base personnel, and the environment. These risks would be controlled through the use of proper health and safety protection procedures and engineering controls, such as the use of dust suppressants and erosion and sedimentation control measures.

Implementation of institutional controls would not pose a short-term risk to human health or the environment since no remedial actions would be implemented other than administrative actions associated with land use restrictions.

Implementability: The technologies for grading and soil cap installation are well-demonstrated and commercially available. Dust and erosion control measures would be required, as well as personnel and perimeter air monitoring to minimize potential human health and environmental risks posed by the earth moving activities.

Institutional controls should be relatively straight forward to implement. Periodic inspection and maintenance of the site fencing and soil cap (e.g., repairing erosion damage) would be required.

Cost: The estimated costs of this alternative are as follows:

- Capital: $2,167,600
- Annual operation and maintenance: $6,400
- Net present worth (30-year): $2,266,000

Detailed cost estimate spreadsheets are provided in Appendix B.

4.4 Alternative SO-4: Composite Cap with Institutional Controls

Description: This alternative includes the placement of a low-permeability composite cap over the landfill. The composite cap would be installed over the eastern and western sections of the landfill as shown in Figure 4-1. The cap sections would encompass areas of approximately 18.4 acres and 3.2 acres, respectively. The existing Seabee Road would remain intact along with its right-of-way, which has been landscaped with trees and shrubs. The main purpose of the cap would be to augment the existing cover system to minimize infiltration of precipitation (i.e., reduce leachate generation) as well as to provide additional protection to both human and ecological (i.e., terrestrial) receptors.

The cap would be constructed in accordance with RCRA Subtitle C and Virginia Hazardous Waste Management Regulations. For costing purposes, it was assumed that the cap would be constructed of a two-foot-thick compacted clay layer overlain by a 30-mil flexible membrane liner constructed of a geosynthetic material, such as very low density polyethylene (VLDPE). The geosynthetic cap would be covered with a drainage layer and a soil layer to support vegetation. A typical cap cross section is shown in Figure 4-3.

Prior to capping, the area would be cleared, grubbed, and stripped of vegetation. In areas containing trees, approximately 6 to 12 inches of soil may need to be removed to remove the bulk of any tree roots. Herbicides may also be applied to prevent regrowth of vegetation following installation of the cap. Following stripping, the soil would be stabilized via mechanical compaction techniques. This would improve the physical properties of the soil and assist in maintaining the integrity of the cap. The soil would be regraded to provide a smooth surface and proper top and side slopes. Additional fill material may need to be imported to fill voids in some areas and provide the proper grades.

A venting system for decomposition gases may not be required because the landfill was used for disposal of non-putrescible wastes.

Surface water runoff would drain into the existing northern drainage ditch and the relocated southern drainage ditch which would be located around the perimeter of the cap. Access to the site would be accommodated via improved (gravel) roadways. A new portion of gravel roadway would be constructed to link the existing northern and the existing southern dirt roadways.

In addition to the composite cap, institutional controls and fencing, as described under Alternative SO-2 (Section 4.2), would also be implemented under this alternative to restrict access to the landfill and limit the site to non-residential use. Fencing for this alternative, however, would also incorporate the installation of additional fencing to completely enclose the site.

Overall Protection: Results of the baseline risk assessment indicate that no unacceptable adverse human health effects would be expected from exposure (via ingestion, inhalation, and dermal contact) to surface soil under the current and future land use of the area for military personnel, child and adult trespassers, future civilian and construction workers, and child and adult residents. The estimated ILCR values were all within the acceptable range of 1.0×10^{-4} to 1.0×10^{-6} under CERCLA. With respect to potential noncarcinogenic health effects, the estimated HI for each receptor and exposure scenario was less than the acceptable level of 1.0 under CERCLA, except for the child resident scenario for which the HI of 1.2 only slightly exceeded 1.0.

The risk assessment also indicates that no unacceptable adverse human health effects would be expected from exposure to subsurface soils under a future use scenario for remedial construction workers. The risk assessment indicates that adverse human health effects may be expected from exposure to subsurface soils for both the future adult and child resident, as the ILCRs were calculated at 3.1×10^{-4} and 1.9×10^{-4}, respectively. Similarly, the HIs calculated for exposure to subsurface soils for the adult and child resident scenarios are 4.8 and 20, respectively, which exceed the acceptable HI of 1.0 under CERCLA. An HI of 5.4 was calculated for the adult construction worker, which also exceeds the acceptable HI of 1.0 under CERCLA.

This alternative would provide protection to human health through installation and maintenance of the low-permeability composite cap, through maintenance of the existing and newly installed site fencing, installation of warning signs, and incorporation of land use restrictions in the Base Master Plan and real estate mapping. These actions would significantly reduce the chance of exposure to potential contaminants within the landfill.

Potential contamination present in the landfill could provide a source of shallow and deep groundwater contamination, particularly in areas where the clay confining layer is not present. The low-permeability cap may reduce the amount of contaminant leaching to groundwater by significantly reducing the amount of infiltration through the fill materials. However, the overall effectiveness of the cap would be limited because the landfill is not lined with a low-permeability material, and the groundwater is very shallow (i.e., approximately 4 to 8 feet bgs) throughout the site. Thus, potentially contaminated soils and debris are located very close to, or beneath, the water table, making it possible for fluctuations in groundwater levels to cause releases of contaminants to groundwater. Potential contamination (i.e., liquid wastes) in the landfill could also flow vertically to groundwater by gravity.

It should be noted that the extent of contamination in the shallow groundwater (water table) aquifer appears to be limited, and the Yorktown Aquifer appears to be only marginally impacted by the site. Therefore, the actual threat of leaching of contaminants from soils to groundwater at the site may be minimal.

Compliance with ARARs: State and federal contaminant-specific ARARs are not available for soils. The only locaiton-specific ARARs associated with this alternative deal with the protection of floodplains (Executive Order 11990 and Code of Virginia - Section 62.1-13.1 and VR 450-01-0051). During installation of the composite cap, care must be taken to minimize the destruction, loss or degradation of existing wetlands during cap installation. The composite cap would be designed to meet the requirements of RCRA Subtitle C (40 CFR Part 264.310) and the Virginia Hazardous Waste Management Regulations (VR 672-10-01, Part X, Section 10.13.K) for capping a hazardous waste landfill, which are relevant and appropriate for the permitted seciton of the landfill. Compliance with these requirements would also meet the closure requirements for construction/demolition debris landfills under the Virginia Solid Waste Regulations (VR 672-20-10, Part V, Section 5.2.E), which are TBC criteria for the unpermitted part of the landfill.

Long-term Effectiveness and Permanence: Institutional controls would be effective in the long-term in restricting the landfill area to non-residential land uses, thereby reducing any health hazards posed by potential contamination in these areas. Thus, this alternative provides a permanent solution in the sense that it provides specific actions for preventing exposure to potential contaminants within the landfill (remedial action objective 1 for soils), as well as contaminants within the surface water and sediments located within the fenced area.

Installation of the cap would help to reduce leaching of potential contaminants from soil to groundwater (remedial action objective 2 for soils). However, as previously indicated, the effectiveness of the cap would be limited by the fact that the site is not underlain by a low-permeability liner and the depth to groundwater is very shallow. Installation of the composite cap, as well as complete enclosure (via fencing) of the site, would minimize direct ecological exposure to surface soils (remedial action objective 3 for soils).

Reduction of Toxicity, Mobility, or Volume: This alternative would not reduce the toxicity, mobility, or volume of potential contaminants through active treatment. There may be a reduction in toxicity and volume of potential organic contaminants in the long-term through natural processes such as biodegradation. Installation of the cap would help to reduce the mobility of potential contaminants in the soil; however, as previously noted, the degree of reduction may be marginal because of the absence of a confining layer and a very shallow groundwater depth.

Short-term Effectiveness: Construction of the cap would require extensive clearing, grubbing, and regrading activities that would disturb some of the landfill contents and potentially pose a risk to workers, nearby Base personnel, and the environment. These risks would be controlled through the use of proper health and safety protection procedures and engineering controls, such as the use of dust suppressants and erosion and sedimentation control measures.

Implementation of institutional controls would not pose a short-term risk to human health or the environment since no remedial actions would be implemented other than administrative actions associated with land use restrictions.

Implementability: The technologies for grading and cap installation are well-demonstrated and commercially available. Dust and erosion control measures would be required, as well as, personnel and perimeter air monitoring to minimize potential human health and environmental risks posed by the earth moving activities. Because the landfill is well-vegetated in some areas, puncturing of the cap from regrowth of vegetation would be a concern. Herbicides could be applied to limit regrowth; however, herbicide application could pose a risk to the environment because of the absence of a liner and the shallow groundwater table.

Institutional controls should be relatively straight forward to implement. Periodic inspection and maintenance of the site fencing and composite cap (e.g., repairing holes in the cap) would be required.

Cost: The estimated costs of this alternative are as follows:

- Capital: $5,916,500
- Annual operation and maintenance: $4,000
- Net present worth (30-year): $5,978,000

Detailed cost estimate spreadsheets are provided in Appendix B.

4.5 Comparison of Alternatives

A comparison of the soil remedial alternatives, based on the seven evaluation criteria used in the previous sections, is presented as follows.

Overall Protection: With respect to surface soils, Alternatives SO-3 and SO-4 would provide the greatest amount of overall protection. Although the institutional controls noted in Alternatives SO-2, SO-3, and SO-4 would help to minimize the chance for exposure to potential contaminants, the soil and composite caps would provide added protection. Alternative SO-1 would not provide any additional protection to human health.

With respect to potential contamination in subsurface soils, Alternative SO-1 would not provide any additional protection to human health. Alternative SO-2 would provide a higher degree of protection through formal institutional controls and maintenance of the existing landfill soil cover and fencing. However, Alternatives SO-3 and SO-4 would provide the highest level of protection through institutional controls and installation of the soil cap and low-permeability cap, respectively.

With respect to groundwater protection, Alternative SO-1 and SO-2 would not provide any actions for minimizing leaching of potential contaminants from soil to groundwater. However, as previously indicated, the threat of contaminant leaching to groundwater may be minimal. Alternatives SO-3 and SO-4 may reduce the amount of contaminant leaching to groundwater; however, the overall effectiveness of either cap would be limited because the landfill is not lined with a low-permeability material, and the groundwater is very shallow.

Compliance with ARARs: There are no contaminant-specific ARARs associated with Alternatives SO-1, SO-2, SO-3, or SO-4. Location-specific ARARs for Alternatives SO-3 and SO-4 deal with the protection of floodplains (Executive Order 11988) and wetlands (Executive Order 11990 and Code of Virginia - Section 62.1-13.1 and VR 450-01-0051). Under Alternatives SO-1 and SO-2, the existing landfill cover would essentially comply with the closure requirements for construction/demolition debris landfills under the Virginia Solid Waste Regulations (VR 672-20-10, Part V, Section 5.2.E) and for hazardous waste landfills under the Virginia Hazardous Waste Regulations (VR 672-10-1, Part X, Section 10.13.K) except for the leachate minimization requirements. Under Alternative SO-3, the new soil cover would be designed and installed to comply with these requirements, again, with the exception of long-term minimization of migration of liquids through the closed landfill. Under Alternative SO-4, the composite cap would be designed to meet the requirements of RCRA Subtitle C (40 CFR Part 264.310) and Virginia Hazardous Waste Management Regulations (VR 672-10-01, Part X, Section 10.13.K) for capping a hazardous waste landfill.

Long-term Effectiveness and Permanence: Estimated risk levels for exposure to surface soils are currently within acceptable levels. Therefore, all alternatives would currently be protective of human health with respect to surface soils.

With respect to remedial action objective 1 for soils, Alternative SO-2 would provide a more permanent solution than would Alternative SO-1 in the sense that it would provide institutional controls for preventing exposure to potential contaminants within the landfill as well as contaminants in the surface water and sediments located on site. Alternatives SO-3 and SO-4 would provide the greatest level of long-term protection through both institutional controls and installation of a permanent cap.

With respect to remedial action objective 2 for soils, Alternatives SO-1 and SO-2 would not provide any actions for minimizing leaching of potential contaminants from soil to groundwater. However, as previously indicated, the threat of contaminant leaching to groundwater may be minimal. Installation of a soil cap under Alternative SO-3 may slightly reduce leaching of potential contaminants from soil to groundwater; while the installation of the composite cap under Alternative SO-4 would help to reduce infiltration and thus leaching of potential contaminants from soil to groundwater. However, as previously indicated, the effectiveness of the soil or the composite cap would be limited by the fact that the site is not underlain by a low-permeability liner and the depth to groundwater is very shallow.

Alternatives SO-1 and SO-2 would not prevent ecological exposure to surface soil (remedial action objective 3 for soils); while Alternatives SO-3 and SO-4 would minimize direct ecological exposure to the surface soil.

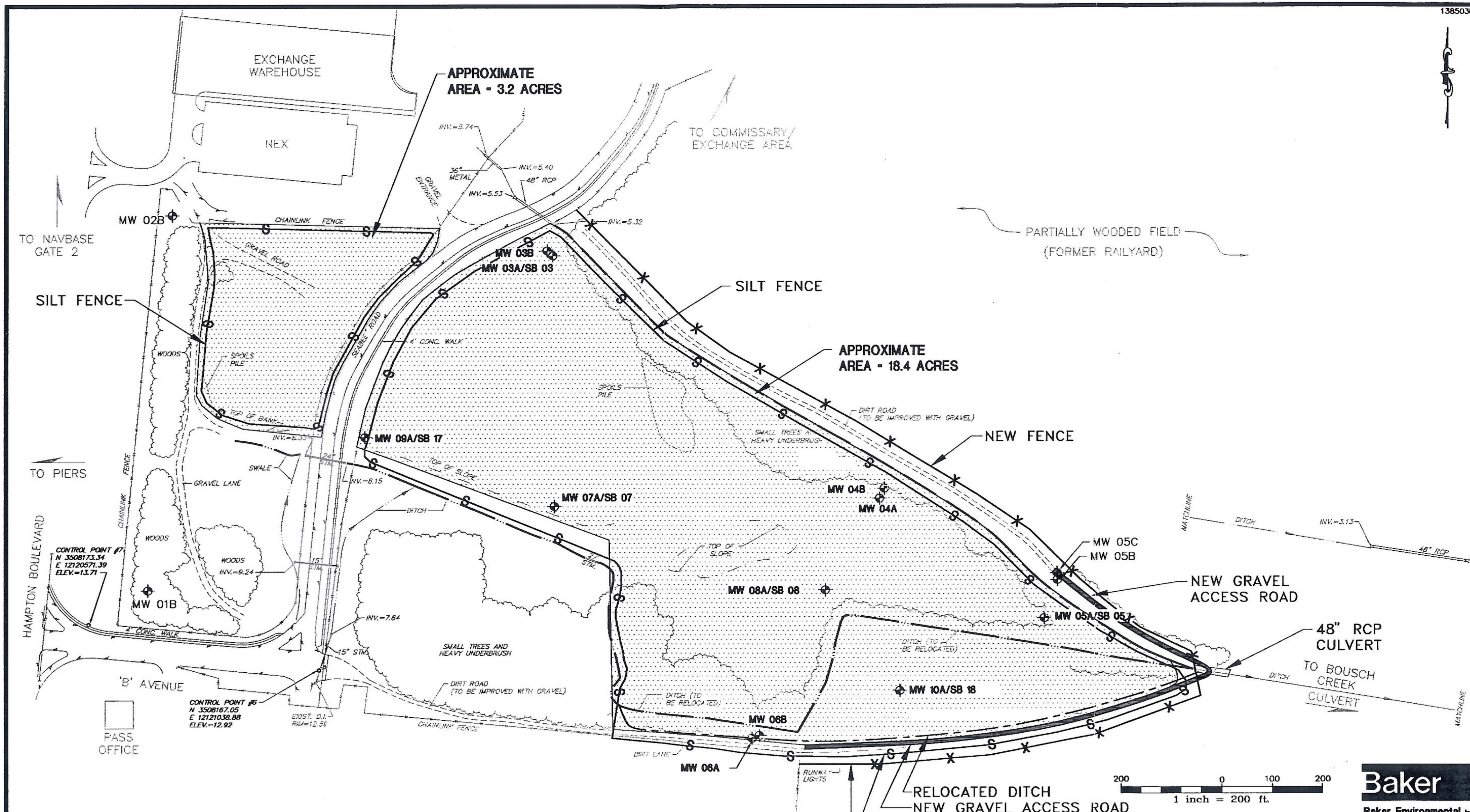
Reduction of Toxicity, Mobility, or Volume: None of the alternatives would actively reduce the toxicity, mobility, or volume of contaminants through treatment. Some reduction may be achieved under these alternatives through natural processes, such as volatilization and biodegradation. Installation of a cap under Alternatives SO-3 and SO-4 would help to reduce the mobility of potential contaminants in the soil, but the degree of reduction may be marginal because of the absence of a confining layer and a very shallow groundwater depth.

Short-term Effectiveness: Alternatives SO-1 and SO-2 would not pose potential risks to human health or the environment during implementation. Construction of a cap under Alternatives SO-3 and SO-4 would require extensive clearing, grubbing, and regrading activities that would disturb some of the landfill contents and potentially pose a risk to workers, nearby Base personnel, and the environment.

Implementability: There are no major implementability considerations under Alternatives SO-1 and SO-2. Alternatives SO-3 and SO-4 would be significantly more difficult to implement than Alternatives SO-1 and SO-2 because of the large area to be capped (approximately 21.6 acres); extensive clearing, grubbing, and regrading required; and the necessary human health and environmental protection measures. The implementability of Alternative SO-4 would be the most cumbersome, as the composite cap would require various media layers and installation techniques.

Cost: The 30-year net present worth costs for the three alternatives are summarized below:

- Alternative SO-1: $0
- Alternative SO-2: $69,000
- Alternative SO-3: $2,266,000
- Alternative SO-4: $5,978,000

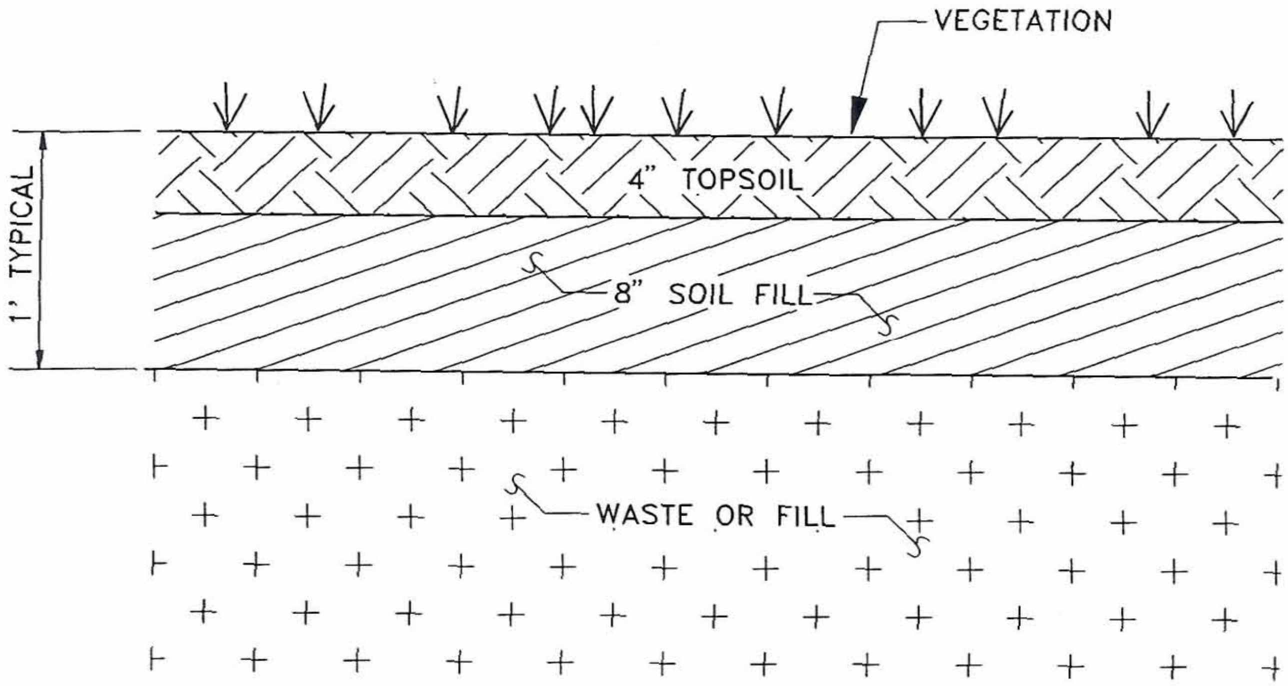


LEGEND

MW 01 (symbol)	EXISTING MONITORING WELL (AND ASSOCIATED BORING) LOCATION
(shaded area)	APPROXIMATE LIMITS OF CAP (ALT. SO-3 – 1' SOIL CAP, ALT. SO-4 – COMPOSITE CAP)
MW 01	MONITORING WELL TO BE ABANDONED

SOURCE: HOGGARD/EURE, SEPTEMBER 1993

FIGURE 4-1
ALTERNATIVES SO-3 AND SO-4:
CAP LOCATIONS
CD LANDFILL
NAVAL BASE NORFOLK
NORFOLK, VIRGINIA



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LEGEND

VEGETATION/TOPSOIL LAYER

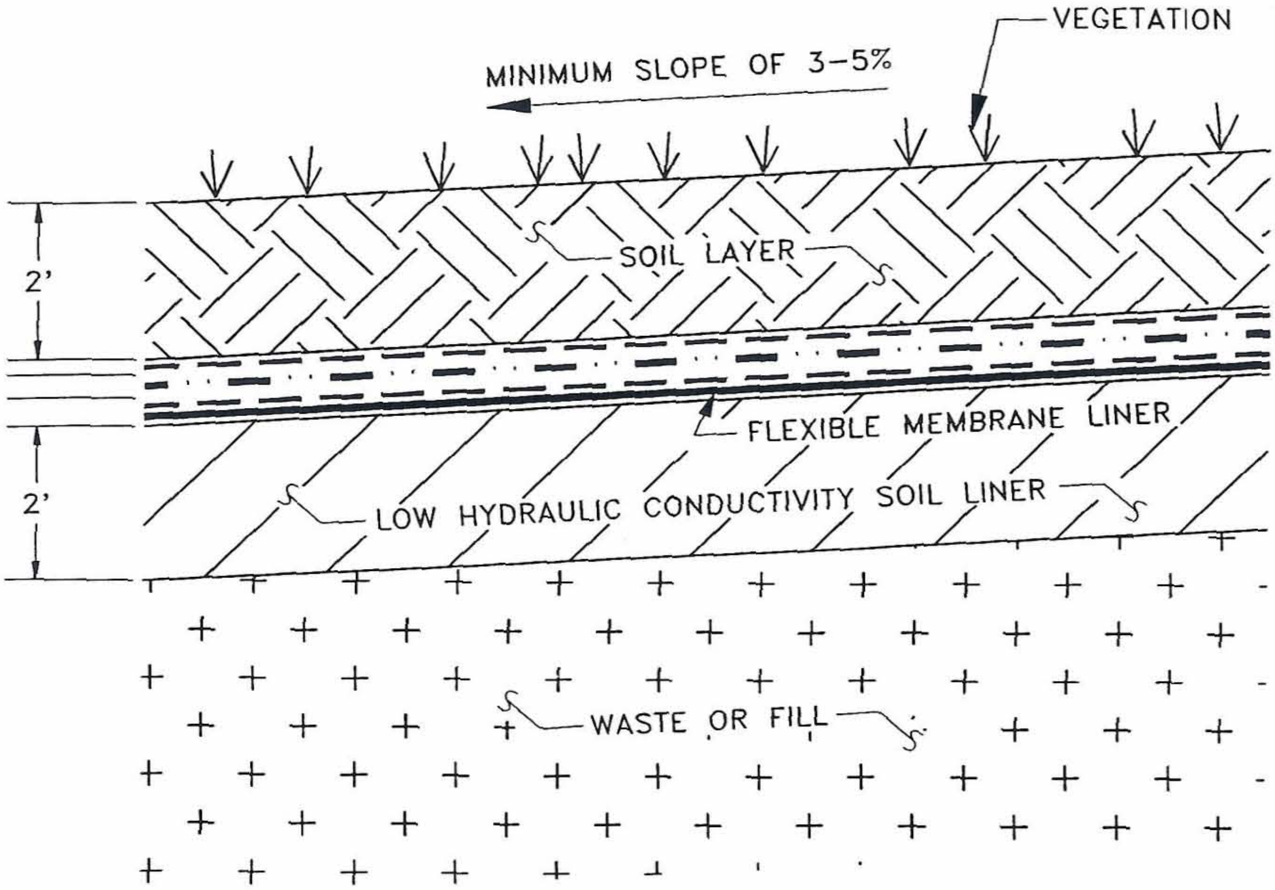
SOIL FILL LAYER

WASTE OR FILL

FIGURE 4-2
ALTERNATIVE SO-3:
1 FOOT THICK SOIL COVER
CD LANDFILL

NAVAL BASE NORFOLK
NORFOLK, VIRGINIA

138508FS



SOURCE: USEPA "DESIGN AND CONSTRUCTION OF RCRA/CERCLA FINAL COVERS," MAY 1991, EPA/625/4-91/025

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LEGEND

- VEGETATION/SOIL LAYER
- GEOTEXTILE (FILTRATION OR FML PROTECTION)
- GEONET (DRAINAGE LAYER)
- FLEXIBLE MEMBRANE LINER (FML) 30 MIL MINIMUM
- LOW HYDRAULIC CONDUCTIVITY SOIL LAYER $k \leq 1\times10^{-7}$ cm/sec
- WASTE OR FILL

FIGURE 4-3
ALTERNATIVE SO-4:
COMPOSITE CAP CROSS-SECTION
CD LANDFILL

NAVAL BASE NORFOLK
NORFOLK, VIRGINIA

5.0 DETAILED ANALYSIS OF GROUNDWATER REMEDIAL ALTERNATIVES

In this section, the general response actions, remedial technologies, and process options retained from the screening and evaluation step in Section 3.0 are combined to form groundwater remedial action alternatives. The following groundwater alternatives have been developed for the CD Landfill Site:

- Alternative GW-1: No Action
- Alternative GW-2: Institutional Controls with Monitoring
- Alternative GW-3: Groundwater Extraction/Treatment with Institutional Controls and Monitoring

As noted in Section 3.0, surface water and sediment monitoring have been included under the groundwater category for purposes of alternative development and evaluation.

The detailed analysis of groundwater alternatives will be conducted in accordance with CERCLA guidance, as discussed in Section 4.0.

5.1 Alternative GW-1: No Action

Description: Evaluation of the No Action Alternative is required by the NCP to provide a baseline comparison for other remediation alternatives. Under the No Action Alternative, no remedial action for groundwater would be performed at the CD Landfill Site.

Overall Protection: Under a future residential use scenario (potable use of shallow groundwater), the baseline risk assessment indicates unacceptable risks for both resident children and adult receptors would be expected from exposure to shallow groundwater via ingestion and dermal contact. However, as previously discussed, the shallow groundwater is not suitable for potable purposes. Under the more plausible potential future use scenario, nonpotable use of shallow groundwater by civilian workers, the baseline risk assessment indicates that an unacceptable risk would be expected from groundwater exposure via dermal contact. Based on results of the human health risk assessment, no unacceptable risks for both resident children and adult receptors would be expected from exposure to deep groundwater via ingestion, dermal contact, and inhalation.

However, since the site is a former landfill that may contain potential sources of contamination, installation of potable supply wells on or adjacent to the landfill could pose a future threat to human health.

Although groundwater is not currently used on site for any purpose, there are no official institutional controls in place to restrict groundwater use. Under this alternative, no specific actions would be taken to prevent future use of either the shallow groundwater table or Yorktown Aquifers.

Under this alternative, the chlorobenzene contamination detected in well MW-05A could eventually migrate and discharge into one or both of the northern and/or southern drainage ditches.

Compliance with ARARs: Contaminant levels in some surface water samples exceeded federal Ambient Water Quality Criteria (AWQC) established under the Clean Water Act (33 USC 1313 and 57 FR 60920-60921) and Virginia Water Quality Standards (WQS) [VR 680-21-01.14]. However, there was no clear pattern of exceedences for most contaminants that could be attributed to specific sources within the landfill. 1,4-dichlorobenzene was detected in two surface water samples in the northern drainage ditch, which may be the result of discharge of contaminated shallow groundwater to the ditch. The concentrations of these detections (1.0 and 0.7 μg/L), however, were well below the federal AWQC and Virginia WQS level (2,600 μg/L).

Federal and state primary MCLs established pursuant to the Safe Drinking Water Act (42 USC 300) and the Virginia Department of Health (VR 355-18-004) are relevant and appropriate for the Yorktown Aquifer beyond the unit boundary, and the secondary MCLs established under these regulations are TBC criteria for this aquifer beyond the unit boundary. The primary and secondary MCLs are not ARARs for the shallow groundwater aquifer since it is not suitable as a potable water supply. The lead concentration in an unfiltered sample from one Yorktown Aquifer well (well MW-5C), located just outside the landfill boundary, slightly exceeded the MCL during Round 1 but did not exceed it during Round 2. Iron and manganese exceeded their secondary MCL values in wells MW-3B and MW-5C; however, these constituents may not be site-related and may be a result of turbidity in the wells caused by well bailing during sampling.

There are no location-or action-specific ARARs associated with this alternative.

Long-term Effectiveness and Permanence: Based on the baseline risk assessment, there appears to be a slight risk associated with nonpotable use of the shallow groundwater aquifer but no unacceptable risks from potable use of the Yorktown Aquifer. However, the landfill may contain potential sources of groundwater contamination, which could contaminate the shallow groundwater and Yorktown Aquifers in the future. Therefore, installation of deep (Yorktown Aquifer) water supply wells on or adjacent to the landfill could pose an unacceptable risk to human health in the future.

This alternative would not provide a permanent solution since no specific actions would be taken to prevent future potential exposure to shallow groundwater exceeding the nonpotable use cleanup levels (remedial action objective 1) or future potable use of the Yorktown Aquifer on site (remedial action objective 5). In addition, this alternative would not actively prevent migration of (remedial action objective 2) or restore shallow groundwater exceeding nonpotable cleanup levels (remedial action objective 3). Thus, this alternative may not prevent the discharge of contaminated shallow groundwater to surface water (remedial action objective 4).

Reduction of Toxicity, Mobility, or Volume: This alternative would not reduce the toxicity, mobility, or volume of potential contaminants in the groundwater through active treatment. However, there may be a reduction in toxicity and volume of contaminants in the long-term through natural processes such as biodegradation, volatilization and dispersion. As previously noted, the extent of contamination in the shallow groundwater aquifer appears to be limited to the vicinity of well MW-05A.

Short-term Effectiveness: This alternative does not involve remedial actions that would pose a risk to human health or the environment during implementation.

Implementability: The No Action Alternative would be both technically and administratively straightforward to implement since there are no remedial activities associated with this alternative.

Cost: There are no costs associated with this alternative.

5.2 Alternative GW-2: Institutional Controls with Monitoring

Description: Under this alternative, institutional controls would be implemented to restrict groundwater use at the site. Although groundwater is not currently used on site for any purpose, there are no official institutional controls in place to restrict groundwater use. A Master Plan for the Base is currently under development. Under this alternative, institutional controls would be incorporated into the Master Plan to prohibit installation of water supply wells (for either potable or nonpotable use) on site. With respect to surface water and sediments at the site, institutional controls and fencing to prevent potential future exposure to potential contaminants within these media are included under Alternative SO-2 for soil (Section 4.0).

A surface water, sediment and groundwater monitoring program would be implemented to track trends in surface water, sediment and groundwater contamination at the site. For surface water and sediment, the monitoring program would include semi-annual sampling and analysis at approximately seven locations along the ditches around the site perimeter. For costing purposes, it was assumed that semi-annual sampling and analysis would be performed for a thirty-year period. After an initial five-year monitoring period, trends would be evaluated and the need for remedial action or continued monitoring would be assessed.

For groundwater, the monitoring program would include semi-annual sampling of seven monitoring wells. For costing purposes, it was assumed that semi-annual sampling and analysis would be performed over a thirty-year period. After an initial five-year monitoring period, trends would be evaluated and the need for remedial action or continued monitoring would be assessed.

Overall Protection: Under a future residential use scenario (potable use of shallow groundwater), the baseline risk assessment indicates unacceptable risks for both resident children and adult receptors would be expected from exposure to shallow groundwater via ingestion and dermal contact. However, as previously discussed, the shallow groundwater is not suitable for potable purposes. Under the more plausible potential future use scenario, nonpotable use of shallow groundwater by civilian workers, the baseline risk assessment indicates that an unacceptable risk would be expected from groundwater exposure via dermal contact. Based on results of the human health risk assessment, no unacceptable risks for both resident children and adult receptors would be expected from exposure to deep groundwater via ingestion, dermal contact, and inhalation.

However, since the site is a former landfill that may contain potential sources of contamination, installation of potable supply wells on or adjacent to the landfill could pose a future threat to human health.

Under this alternative, institutional controls would be implemented to prevent future use of the shallow groundwater and Yorktown Aquifers on site. The chlorobenzene contamination detected in well MW-05A could eventually migrate and discharge into one or both of the northern and southern drainage ditches. A surface water, sediment, and groundwater monitoring program would be implemented to track contamination trends in these media.

Compliance with ARARs: Contaminant levels in some surface water samples exceeded federal AWQC established under the Clean Water Act (33 USC 1313 and 57 FR 60920-60921) and Virginia WQS (VR 680-21-01.14). However, there was no clear pattern of exceedences for most contaminants that could be attributed to specific sources within the landfill. 1,4-dichlorobenzene was detected in two surface water samples in the northern drainage ditch, which may be the result of discharge of contaminated shallow groundwater to the ditch. The concentrations of these detections (1.0 and 0.7 µg/L), however, were well below the federal AWQC and Virginia WQS level (2,600 µg/L).

Federal and state primary MCLs established pursuant to the Safe Drinking Water Act (42 USC 300) and the Virginia Department of Health (VR 355-18-004) are relevant and appropriate for the Yorktown Aquifer beyond the unit boundary, and the secondary MCLs established under these regulations are TBC criteria for this aquifer beyond the unit boundary. The primary and secondary MCLs are not ARARs for the shallow groundwater aquifer since it is not suitable as a potable water supply. The lead concentration in an unfiltered sample from one Yorktown Aquifer well (well MW-5C), located just outside the landfill boundary, slightly exceeded its MCL during Round 1, but did not exceed its MCL during Round 2. Iron and manganese exceeded their secondary MCL values in wells MW-3B and MW-5C; however, these constituents may not be site-related and may be a result of turbidity in the wells caused by well bailing during sampling.

There are no location-or action-specific ARARs associated with this alternative.

Long-term Effectiveness and Permanence: Based on the baseline risk assessment, there appears to be a slight risk associated with nonpotable use of the shallow groundwater aquifer but no unacceptable risks from potable use of the Yorktown Aquifer. However, the landfill may contain potential sources of groundwater contamination, which could contaminate the shallow groundwater and Yorktown Aquifers in the future. Therefore, installation of deep (Yorktown Aquifer) water supply wells on or adjacent to the landfill could pose an unacceptable risk to human health in the future.

This alternative would provide a permanent solution through use of institutional controls to prevent future potential exposure to shallow groundwater exceeding the nonpotable use cleanup levels (remedial action objective 1) and future potable use of the Yorktown Aquifer on site (remedial action objective 5). This alternative would not actively prevent migration of (remedial action objective 2) or restore shallow groundwater exceeding nonpotable cleanup levels (remedial action objective 3). Thus, this alternative may not prevent the discharge of contaminated shallow groundwater to surface water (remedial action objective 4). The surface water, sediment, and groundwater monitoring program would provide information needed to evaluate contaminant levels in these media and to evaluate the need for potential future remedial actions.

Reduction of Toxicity, Mobility, or Volume: This alternative would not reduce the toxicity, mobility, or volume of potential contaminants in the surface water, sediment, or groundwater through active treatment. However, there may be a reduction in toxicity and volume of contaminants in the long-term through natural processes such as biodegradation, volatilization and dispersion. The extent of contamination in the water table aquifer may be limited to the vicinity of well MW-05A.

Short-term Effectiveness: This alternative does not involve remedial actions that would pose a risk to human health or the environment during implementation.

Implementability: Institutional controls should be administratively straightforward to implement. The monitoring program would utilize standard sample collection and analytical methodologies. Equipment and services for sampling are readily available. In accordance with CERCLA, a site review would be required every five years to evaluate long-term contaminant trends and any associated risks to human health and the environment.

Cost: The estimated costs of this alternative are as follows:

- *Capital:* $0
- Annual operation and maintenance: $66,600
- Net present worth (30-year): $1,024,000

Detailed cost estimate spreadsheets are provided in Appendix B.

5.3 Alternative GW-3: Groundwater Extraction with Institutional Controls and Monitoring

Description: The objective of this alternative is to use groundwater extraction and treatment technology, also referred to as "pump and treat", to contain and restore groundwater contaminated above the nonpotable use cleanup levels to render it suitable for its most likely potential beneficial use (i.e., nonpotable use such as lawn watering and vehicle washing). As discussed in Section 1.5, the major contaminant contributing to the risk under this exposure scenario is chlorobenzene. Chlorobenzene was detected in monitoring well MW-05A during sampling rounds 1 and 2 at concentrations of 1,950 µg/L and 1,000 µg/L, respectively. In addition to chlorobenzene, 1,4-dichlorobenzene was detected in monitoring well MW-05A and in two surface water samples. The following cleanup levels were developed for chlorobenzene and 1,4-dichlorobenzene based on the nonpotable use scenario:

- chlorobenzene: 100 µg/L
- 1,4-dichlorobenzene: 20 µg/L

The cleanup level for the 1,4-dichlorobenzene is based on an ILCR of 1×10^{-5}. The chlorobenzene cleanup level is based on an HI of 0.1. These cleanup levels should be protective of surface water in the drainage ditches since they are less than their respective federal AWQC and Virginia WQC standards.

Pump and treat has traditionally been the most commonly selected alternative for containment and remediation of contaminant plumes. Under this alternative, groundwater would be pumped using three shallow (approximately 25 feet deep) pumping wells connected to a common treatment system.

An estimated groundwater pumping rate of approximately 15 gallons per minute would be required to contain the assumed extent of contamination. The conceptual pumping wells and treatment plant locations are shown in Figure 5-1. Each well would pump water at approximately 5 gallons per minute, for a total pumping rate of about 15 gallons per minute. The conceptual extraction system was developed based on the pumping rate necessary to contain the plume, the number of wells needed to achieve the pumping rate, and the optimum spacing between the wells to capture the groundwater.

The conceptual treatment system design for this alternative (Figure 5-2) is based on a granular activated carbon (GAC) system for removal of the organic contaminants (primarily chlorobenzene). As discussed in Section 3.3, GAC was selected as the representative process option since it is well-proven, economical for low flow rates, and relatively straightforward to install and operate. Air stripping and UV/peroxide oxidation were eliminated as representative process options but could be reconsidered during the design phase (if this alternative is selected). As shown in Figure 5-2, sand and cartridge filters were included in the treatment system for removal of suspended solids to minimize clogging of the GAC units. Treated groundwater would be discharged into the existing on-site drainage ditch as shown in Figure 5-1. The water would be treated to comply with effluent standards established in accordance with the substantive requirements of the Virginia Pollutant Discharge Elimination System (VPDES). For cost estimating purposes, it was assumed that the treatment system would be housed in a permanent, block-type building constructed on site.

Institutional controls would be implemented to restrict groundwater use at the site. Although groundwater is not currently used on site for any purpose, there are no official institutional controls in place to restrict groundwater use. A Master Plan for the Base is currently under development. Under this alternative, institutional controls would be incorporated into the Master Plan to prohibit installation of water supply wells (for either potable or nonpotable use) on site. With respect surface water and sediments at the site, institutional controls and fencing to prevent potential future exposure to potential contaminants within these media are included under Alternative SO-2 for soil (Section 4.0).

A surface water, sediment and groundwater monitoring program would be implemented to track trends in surface water, sediment and groundwater contamination at the site. For surface water and sediment, the monitoring program would include semi-annual sampling and analysis at approximately seven locations along the ditches around the site perimeter. For costing purposes, it was assumed that semi-annual sampling and analysis would be performed for a thirty-year period. After an initial five-year monitoring period, trends would be evaluated and the need for remedial action or continued monitoring would be assessed.

For groundwater, the monitoring program would include semi-annual sampling of seven monitoring wells. For costing purposes, it was assumed that semi-annual sampling and analysis would be performed over a thirty-year period. After an initial five-year monitoring period, trends would be evaluated and the need for remedial action or continued monitoring would be assessed.

Overall Protection: Under a future residential use scenario (potable use of shallow groundwater), the baseline risk assessment indicates unacceptable risks for both resident children and adult receptors would be expected from exposure to shallow groundwater via ingestion and dermal contact. However, as previously discussed, the shallow groundwater is not suitable for potable purposes. Under the more plausible potential future use scenario, nonpotable use of shallow groundwater by civilian workers, the baseline risk assessment indicates that an unacceptable risk would be expected from groundwater exposure via dermal contact. Based on results of the human health risk assessment, no unacceptable risks for both resident children and adult receptors would be expected from exposure to deep groundwater via ingestion, dermal contact, and inhalation. However, since the site is a former landfill that may contain potential sources of contamination, installation of potable supply wells on or adjacent to the landfill could pose a future threat to human health.

Under this alternative, institutional controls would be implemented to prevent future nonpotable use of the shallow groundwater until it is restored to the nonpotable use cleanup levels. Institutional controls would also be implemented to prevent future potable use of the Yorktown Aquifer on site. The groundwater extraction and treatment system would contain the extent of chlorobenzene contamination and prevent it from discharging into one or both of the northern and southern drainage ditches. The surface water, sediment, and groundwater monitoring program would be used to track contamination trends in these media and evaluate the effectiveness of the "pump and treat" system.

Compliance with ARARs: Contaminant levels in some surface water samples exceeded federal AWQC established under the Clean Water Act (33 USC 1313 and 57 FR 60920-60921) and Virginia

WQS (VR 680-21-01.14). However, there was no clear pattern of exceedences for most contaminants that could be attributed to specific sources within the landfill. 1,4-dichlorobenzene was detected in two surface water samples in the northern drainage ditch, which may be the result of discharge of contaminated shallow groundwater to the ditch. The concentrations of these detections (1.0 and 0.7 μg/L), however, were well below the federal AWQC and Virginia WQS level (2,600 μg/L).

Federal and state primary MCLs established pursuant to the Safe Drinking Water Act (42 USC 300) and the Virginia Department of Health (VR 355-18-004) are relevant and appropriate for the Yorktown Aquifer beyond the unit boundary, and the secondary MCLs established under these regulations are to-be-considered criteria for this aquifer beyond the unit boundary. The primary and secondary MCLs are not ARARs for the water table aquifer since it is not suitable as a potable water supply. The lead concentration in an unfiltered sample from one Yorktown Aquifer well (well MW-5C), located just outside the landfill boundary, slightly exceeded its MCL during Round 1, but did not exceed its MCL during Round 2. Iron and manganese exceeded their secondary MCL values in wells MW-3B and MW-5C; however, these constituents may not be site-related and may be a result of turbidity in the wells caused by well bailing during sampling.

There are no location-specific ARARs associated with this alternative. The primary action-specific ARARs associated with this alternative are the substantive VPDES requirements of the Virginia Water Pollution Control Regulations (VR 680-14-01).

Long-term Effectiveness and Permanence: Based on the baseline risk assessment, there appears to be a slight risk associated with nonpotable use of the shallow groundwater aquifer but no unacceptable risks from potable use of the Yorktown Aquifer. However, the landfill may contain potential sources of groundwater contamination, which could contaminate the shallow groundwater and Yorktown Aquifers in the future. Therefore, installation of deep (Yorktown Aquifer) water supply wells on or adjacent to the landfill could pose an unacceptable risk to human health in the future.

This alternative would provide a permanent solution through groundwater treatment and via the use of institutional controls to prevent future potential exposure to shallow groundwater exceeding the nonpotable use cleanup levels until it is restored (remedial action objective 1). The institutional controls would also prevent the future potable use of the Yorktown Aquifer on site (remedial action objective 5). This alternative would actively prevent migration of shallow groundwater exceeding nonpotable cleanup levels (remedial action objective 2) and would ultimately restore groundwater to these levels (remedial action objective 3). Thus, this alternative would also prevent the discharge of contaminated shallow groundwater to surface water (remedial action objective 4).

Reduction of Toxicity, Mobility, or Volume: This alternative would reduce the toxicity, mobility, and volume of contaminants in groundwater through active treatment and would potentially reduce the volume of contaminants in adjacent surface waters and sediments. Chlorobenzene in the groundwater would be reduced from its present level to its nonpotable use cleanup level.

Short-term Effectiveness: The primary remedial actions that would pose a risk to human health or the environment during implementation of this alternative would be installation of underground piping for the groundwater extraction system and construction of the treatment building foundation. Since these actions would disturb the landfill subsoils, proper personnel health and safety procedures and environmental protection measures (e.g., dust and erosion controls) would be required to minimize these risks.

Implementability: GAC is commonly used for treatment or organic contaminants in groundwater. Equipment and services for these systems are offered by numerous commercial vendors. Operation of the system would require periodic replacement of the GAC units and occasional disposal (nonhazardous) of accumulated sludge (i.e., inert suspended solids). Institutional controls should be administratively straight forward to implement. The monitoring program would utilize standard sample collection and analytical methodologies. Equipment and services for sampling are readily available. In accordance with CERCLA, a site review would be required every five years to evaluate long-term contaminant trends and any associated risks to human health and the environment.

Cost: The estimated costs of this alternative are as follows:

- Capital: $954,900
- Annual operation and maintenance: $97,600
- Net present worth (30-year): $2,455,000

Detailed cost estimate spreadsheets are provided in Appendix B.

5.4 Comparison of Alternatives

A comparison of the alternatives, based on the seven evaluation criteria used in the previous sections, is presented in the following sections.

Overall Protection: Alternative GW-1, No Action, would provide the lowest level of protection since no formal institutional controls are currently in place for the groundwater. Alternative GW-2 would provide more overall protection than would Alternative GW-1 through the use of institutional controls and monitoring. Alternative GW-3 would provide the highest level of protection since the groundwater extraction and treatment system would contain and treat the extent of chlorobenzene contamination and prevent it from discharging into one or both of the northern and southern drainage ditches.

Compliance with ARARs: There are no location-or action-specific ARARs associated with Alternatives GW-1 and GW-2. Under current site conditions, there are no differences between Alternatives GW-1 and GW-2 with respect to contaminant-specific ARARs. However, Alternatives GW-2 and GW-3 would enable contaminant levels to be tracked and compared to state and federal MCLs and would prevent potential future consumption of groundwater exceeding MCLs through institutional controls.

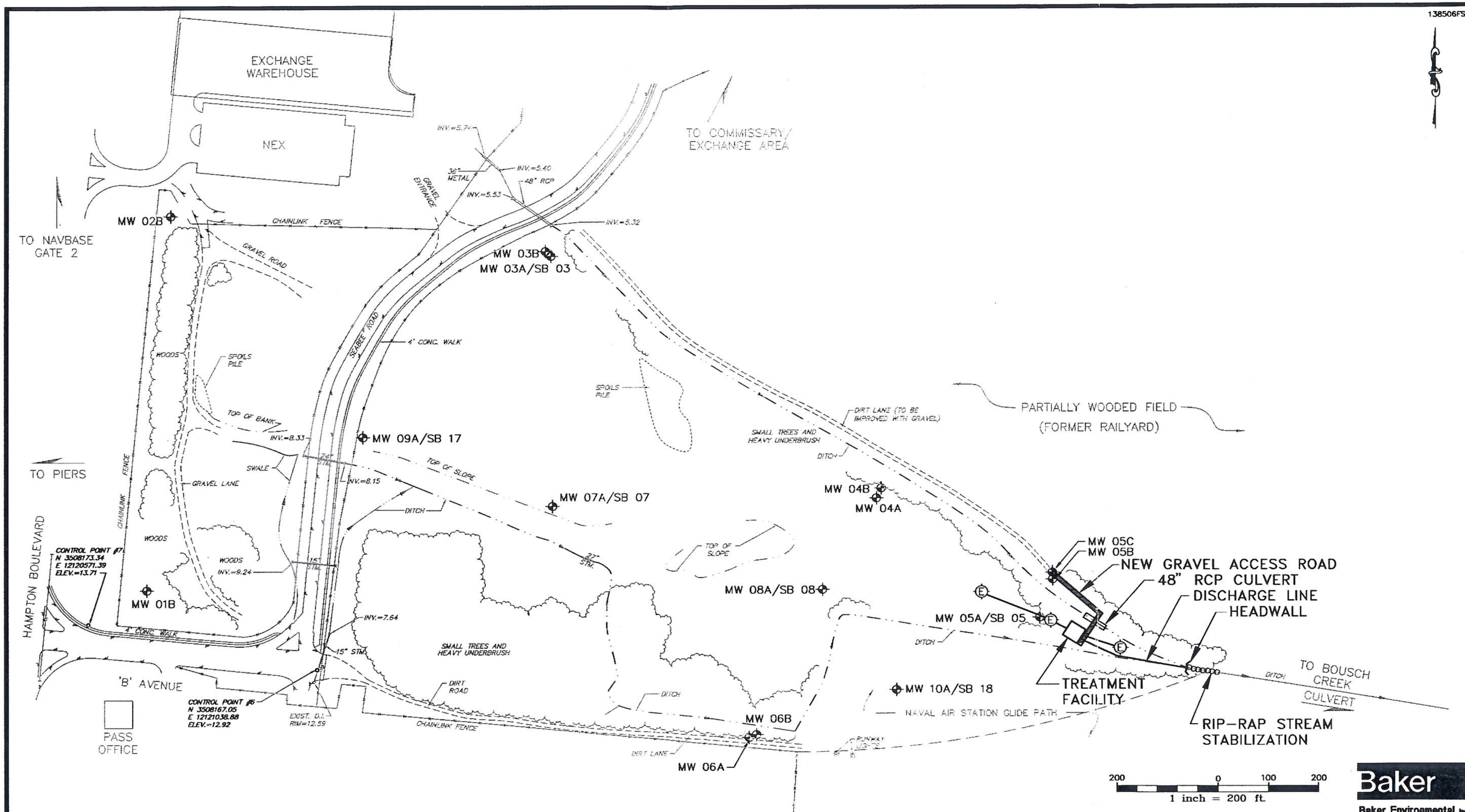
Long-term Effectiveness and Permanence: Alternative GW-1 would achieve the lowest degree of long-term protection since it would not achieve the remedial action objectives. Alternative GW-2 would provide a permanent solution through use of institutional controls to prevent future potential exposure to shallow groundwater exceeding the nonpotable use cleanup levels (remedial action objective 1) and future potable use of the Yorktown Aquifer on site (remedial action objective 5). Only Alternative GW-3 would actively prevent migration of shallow groundwater exceeding nonpotable cleanup levels (remedial action objective 2) and would ultimately restore groundwater to these levels (remedial action objective 3). Thus, this alternative, which would also prevent the discharge of contaminated shallow groundwater to surface water (remedial action objective 4), would achieve the highest level of protection among the three alternatives. However, as previously discussed, the extent of contamination in the water table aquifer may to be limited to the vicinity of well MW-5A.

Reduction of Toxicity, Mobility, or Volume: Alternatives GW-1 and GW-2 would not actively reduce the toxicity, mobility, or volume of contaminants through remedial actions. Some reduction may be achieved under these alternatives through natural processes, such as dispersion, volatilization, and biodegradation. Only Alternative GW-3 would reduce the toxicity, mobility, and volume of contaminants through groundwater extraction and treatment.

Short-term Effectiveness: Alternatives GW-1 and GW-2 would not pose potential risks to human health or the environment during implementation. Alternative GW-3 would pose a risk to human health or the environment during installation of underground piping for the groundwater extraction system and construction of the treatment building foundation. Proper personnel health and safety procedures and environmental protection measures (e.g., dust and erosion controls) would be used to minimize these risks.

Implementability: There are no major implementability considerations associated with Alternatives GW-1 and GW-2. Alternatives GW-2 and GW-3 would involve administrative actions as well as long-term monitoring activities. Alternative GW-3 would be the most difficult to implement but should not pose any significant implementability concerns.

Cost: There are no costs associated with Alternative GW-1. The 30-year net present worth cost for Alternative GW-2 is $1,024,000, whereas the 30-year net present worth cost for Alternative GW-3 is $2,455,000.



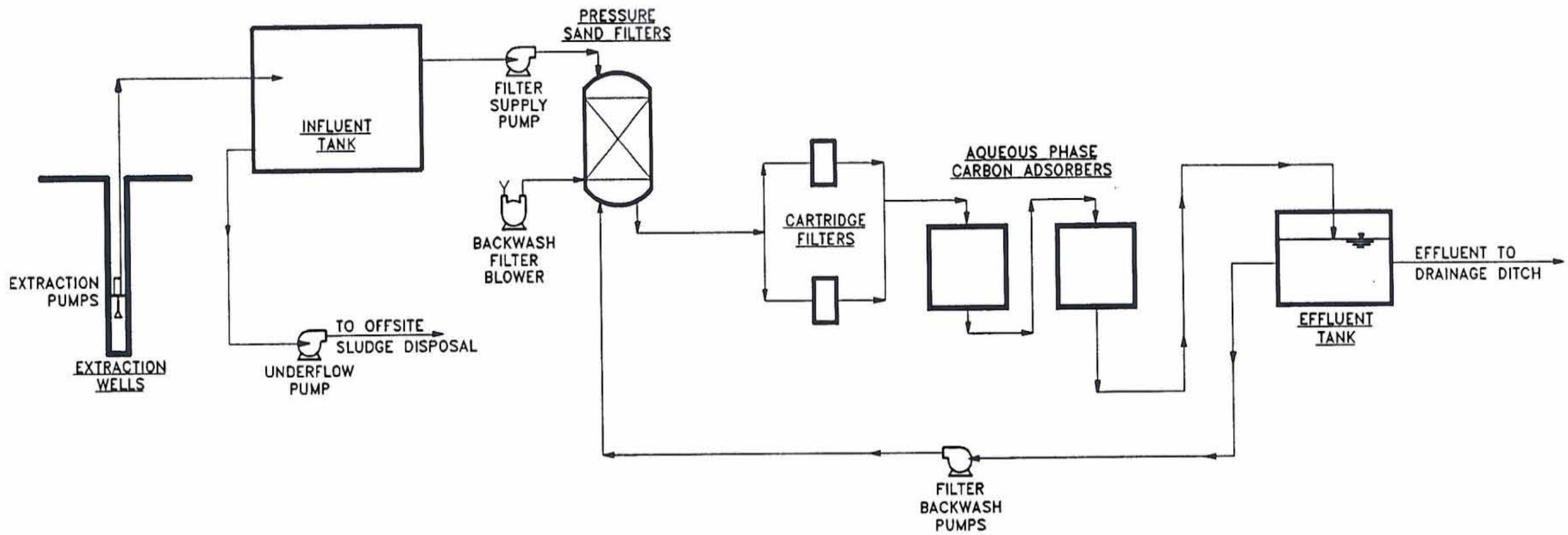
LEGEND

MW 01 EXISTING MONITORING WELL (AND ASSOCIATED BORING) LOCATION

Ⓔ PROPOSED EXTRACTION WELL (5 GPM EACH, 150 FT. SPACING)

SOURCE: HOGGARD/EURE, SEPTEMBER 1993

FIGURE 5–1
ALTERNATIVE GW–03: EXTRACTION AND ON–SITE TREATMENT
CD LANDFILL
NAVAL BASE NORFOLK
NORFOLK, VIRGINIA



Baker
Baker Environmental, Inc.

FIGURE 5-2
ALTERNATIVE GW-03:
GROUNDWATER TREATMENT SYSTEM
PROCESS FLOW DIAGRAM
CD LANDFILL
NAVAL BASE NORFOLK
NORFOLK, VIRGINIA

138509FS

6.0 DETAILED ANALYSIS OF SEDIMENT REMEDIAL ALTERNATIVES

In this section, the general response actions, remedial technologies, and process options retained from the screening and evaluation step in Section 3.0 are combined to form sediment remedial action alternatives. The following sediment alternatives have been developed for the CD Landfill Site:

- Alternative SD-1: No Action
- Alternative SD-2A: Removal and Off-Site Disposal of Sediments Exceeding ER-L Cleanup Levels
- Alternative SD-2B: Removal and Off-Site Disposal of Sediments Exceeding ER-M Cleanup Levels

As noted in Sections 3.0 and 5.0, and for purpose of alternative development and evaluation, the groundwater Alternatives GW-2 and GW-3 include sediment monitoring/sampling. Therefore, provisions for sediment monitoring/sampling will not be repeated within the above noted sediment alternatives. In addition, institutional controls for the sediments were included under the soil remedial alternatives (Alternatives SO-2, SO-3 and SO-4) discussed in Section 4.0.

The detailed analysis of sediment alternatives will be conducted in accordance with CERCLA guidance, as discussed in Section 4.0.

6.1 Alternative SD-1: No Action

Description: Evaluation of the No Action Alternative is required by the NCP to provide a baseline comparison for other remediation alternatives. Under the No Action Alternative, no remedial action would be performed for the sediments at the CD Landfill Site.

Overall Protection: Results of the baseline risk assessment indicate that contamination in the shallow sediments (to 1 foot bgs) would pose a slightly unacceptable risk to human health under the exposure scenarios for current/future adult trespassers, future civilian workers and for future on-site adult residents. Contamination in the deep sediments (2.0 to 2.5 feet bgs) did not result in an unacceptable risk to human health under any of the current or the future site use scenarios. However, results of the ecological risk assessment indicate that both the shallow and the deep sediments may pose a risk to the ecological receptors. This alternative would not provide any protection for the ecological receptors.

Compliance with ARARs: There are no contaminant-, location-, or action-specific ARARs associated with this alternative.

Long-term Effectiveness and Permanence: This alternative would not provide a permanent solution since no specific actions would be taken to reduce the sediment contamination. Likewise, this alternative would not prevent potential future exposure to sediment contaminants.

Reduction of Toxicity, Mobility, or Volume: This alternative would not reduce the toxicity, mobility, or volume of potential contaminants in the sediment through active treatment. However, there may be a reduction in the toxicity and volume of contamination in the long-term through natural processes such as biodegradation, volatilization and dispersion.

Short-term Effectiveness: This alternative does not involve remedial actions that would pose risks to human health or the environment during implementation.

Implementability: The No Action Alternative would be both technically and administratively straight forward to implement since there are no remedial activities associated with this alternative.

Cost: There are no costs associated with this alternative.

6.2 Alternative SD-2A: Removal and Off-Site Disposal of Sediments Exceeding ER-L Cleanup Levels

Description: Under this alternative, sediment exceeding the established ER-L cleanup levels would be excavated from the adjacent ditches. Shallow sediments (to 1 foot bgs) would be excavated from the majority of the existing ditches, while the deeper sediments (from 1 foot to 2.5 feet bgs) exceeding the ER-L cleanup levels (Table 2-4) would be selectively removed. Figure 2-1 graphically displays the proposed sediment excavation locations. The estimated volume of sediment exceeding the ER-L cleanup levels is 980 CY. The excavated sediments would be allowed to air dry on-site, and would then be transported to an off-site non-hazardous disposal facility. As discussed in Section 3.2, the sediments most likely would not be classified as a RCRA characteristic or listed hazardous waste based on the concentrations and origins of the contaminants. For cost estimating purposes, it was assumed that the sediments would be disposed in a nonhazardous disposal cell in an out-of-state landfill located approximately 375 miles from the site. The landfill accepts both hazardous and nonhazardous waste, with a disposal cost of about \$105/ton for nonhazardous sediment and \$220/ton for hazardous sediment.

As previously mentioned, long-term sediment monitoring is presented under Alternatives GW-2 and GW-3. Therefore, sediment monitoring will not be repeated within this alternative. Institutional controls for the sediments were included under the soil remedial alternatives (Alternatives SO-2, SO-3 and SO-4) discussed in Section 4.0.

Overall Protection: Results of the baseline risk assessment indicate that contamination in the shallow sediments (to 1 foot bgs) would pose a slightly unacceptable risk to human health under the exposure scenarios for current/future adult trespassers, future civilian workers and for future on-site adult residents. Results of the ecological risk assessment indicate that both the shallow and the deep sediments may pose a risk to the ecological receptors. These risks would be mitigated through excavation (cleanup) of the contaminated sediments to the ER-L cleanup levels.

Compliance with ARARs: This alternative would remediate the sediments to the ER-L cleanup levels, which are not ARARs, but could be considered TBC criteria. Location-specific ARARs associated with this alternative involve protection of floodplains (Executive Order 11988) and protection of wetlands (Executive Order 11990 and Code of Virginia, Sections 62.1-13.1 and VR 450-01-0051). During excavation of the sediments, care must be taken to minimize the destruction, loss, or degradation of existing wetlands in the vicinity of the drainage ditches. The primary action-specific ARAR associated with sediment removal are the Virginia Stormwater Management and Erosion and Sediment Control Regulations (VR 215-02-00 and VR 625-02-00). Prior to removal of the sediments, an erosion and sedimentation control plan would be developed, outlining engineering controls to be used in the field for ensuring compliance with these regulations.

Long-term Effectiveness and Permanence: Excavation of the shallow and deep sediments that exceed the ER-L cleanup levels would prevent human exposure to contaminated sediments (remedial action objective 1 for sediments), as well as prevent ecological exposure to contaminated sediments (remedial action objective 2 for sediments). In addition, a sediment monitoring program (included under groundwater alternatives GW-2 and GW-3) would provide information needed to evaluate future sediment contaminant levels and to evaluate the need for potential future remedial actions.

Reduction of Toxicity, Mobility, or Volume: *This alternative would reduce the volume of* contaminated sediments on site through removal and off-site disposal. The mobility of the contaminants would be reduced through containment in a secure (i.e., double-lined) disposal cell.

Short-term Effectiveness: This alternative involves remedial actions that may pose a risk to human health or the environment during implementation; as the sediments would be excavated, handled and transported off-site. These risks would be controlled through proper health and safety procedures, environmental protection measures (e.g., erosion and sedimentation controls), and emergency response procedures.

Implementability: Sediment removal and off-site disposal would be administratively straight forward to implement, as the required excavation techniques are standard construction practices. Equipment and services for sediment excavation, hauling and off-site disposal are readily available.

Cost: The estimated costs of this alternative are as follows:

- Capital: $ 721,700
- Operation and maintenance: $ 3,000
- Net present worth (30-year): $ 768,000

Detailed cost estimate spreadsheets are provided in Appendix B.

6.3 Alternative SD-2B: Removal and Off-Site Disposal of Sediments Exceeding ER-M Cleanup Levels

Description: Under this alternative, sediment exceeding the established ER-M cleanup levels would be excavated from the adjacent ditches. The ER-M cleanup levels (Table 2-4) would provide protection of human health for the civilian worker and trespasser scenarios for all contaminants except for arsenic. Therefore, the risk-based cleanup level for arsenic for a civilian worker (Table 2-3) would be used in place of the ER-M value for this alternative. Shallow sediments (to 1 foot bgs) and deep sediments (from 1 foot to 2.5 feet bgs) would be excavated from a selected areas (Figure 2-2) along the existing ditches. The estimated volume of sediment exceeding the ER-M cleanup levels is 190 CY. Similar to Alternative SD-2A, the excavated sediments would be allowed to air dry on-site, and would then be transported to an off-site non-hazardous disposal facility.

As previously mentioned, long-term sediment monitoring is presented under Alternatives GW-2 and GW-3. Therefore, sediment monitoring will not be repeated within this alternative. Institutional controls for the sediments were included under the soil remedial alternatives (Alternatives SO-2, SO-3 and SO-4) discussed in Section 4.0.

Overall Protection: Results of the baseline risk assessment indicate that contamination in the shallow sediments (to 1 foot bgs) would pose a slightly unacceptable risk to human health under the exposure scenarios for current/future adult trespassers, future civilian workers and for future on-site adult residents. However, results of the ecological risk assessment indicate that both the shallow and the deep sediments may pose a risk to the ecological receptors. These risks would be mitigated through excavation (cleanup) of the contaminated sediments to the ER-M cleanup levels.

Compliance with ARARs: This alternative would remediate the sediments to the ER-M cleanup levels, which are not ARARs, but could be considered TBC criteria. Location-specific ARARs associated with this alternative involve protection of floodplains (Executive Order 11988) and protection of wetlands (Executive Order 11990 and Code of Virginia, Sections 62.1-13.1 and VR 450-01-0051). During excavation of the sediments, care must be taken to minimize the destruction, loss, or degradation of existing wetlands in the vicinity of the drainage ditches. The primary action-specific ARAR associated with sediment removal are the Virginia Stormwater Management and

Erosion and Sediment Control Regulations (VR 215-02-00 and VR 625-02-00). Prior to removal of the sediments, an erosion and sedimentation control plan would be developed, outlining engineering controls to be used in the field for ensuring compliance with these regulations.

Long-term Effectiveness and Permanence: Excavation of the shallow and deep sediments that exceed the ER-M cleanup levels would prevent both human and ecological exposure to contaminated sediments (remedial action objectives 1 and 2 for sediments). In addition, a sediment monitoring program (included under groundwater alternatives GW-2 and GW-3) would provide information needed to evaluate future sediment contaminant levels and to evaluate the need for potential future remedial actions.

Reduction of Toxicity, Mobility, or Volume: This alternative would reduce the volume of contaminated in the sediments on site through removal and off-site disposal. The mobility of the contaminants would be reduced through containment in a secure (i.e., double-lined) disposal cell.

Short-term Effectiveness: This alternative involves remedial actions that may pose a risk to human health or the environment during implementation; as the sediments would be excavated, handled, and transported off-site. These risks would be controlled through proper health and safety procedures, environmental protection measures (e.g., erosion and sedimentation controls), and emergency response procedures.

Implementability: Sediment removal and off-site disposal should be administratively straight forward to implement, as the excavation techniques are standard construction practices. Equipment and services for sediment excavation, hauling and off-site disposal are readily available.

Cost: The estimated costs of this alternative are as follows:

- Capital: $ 178,500
- Operation and maintenance: $ 1,000
- Net present worth (30-year): $ 194,000

Detailed cost estimate spreadsheets are provided in Appendix B.

6.4 Comparison of Sediment Alternatives

A comparison of the sediment alternatives, based on the seven evaluation criteria used in the previous sections, is presented as follows.

Overall Protection: Alternative SD-1 would not provide any additional protection to human health than is currently provided by the existing site fencing. Alternative SD-2A would provide a higher degree of protection through active removal and off-site disposal in accordance with the ER-L cleanup levels. Alternative SD-2B would also provide protection through active sediment removal and off-site disposal; however, this protection would be provided in accordance with the ER-M cleanup levels, which are significantly higher than the ER-L cleanup levels (Table 2-4). Therefore, a much larger volume of contaminated sediment would be removed under Alternative SD-2A (980 CY) compared to Alternative SD-2B (190 CY).

Compliance with ARARs: Alternative SD-1 would provide no sediment remediation. However, there are currently no State or federal contaminant-specific ARARs for sediments. Alternative SD-2A would remediate the sediments to the ER-L cleanup levels, whereas, Alternative SD-2B would remediate the sediments to the ER-M cleanup levels, which are less conservative than the ER-L values. Both the ER-L and ER-M criteria are not ARARs, but could be considered TBC criteria. The location- and action-specific ARARs for Alternatives SD-2A and SD-2B are essentially identical. There are no location- or action-specific ARARs associated with Alternative SD-1, since no actions would be taken.

Long-term Effectiveness and Permanence: Alternatives SD-2A and SD-2B would provide a permanent solution through sediment removal and off-site disposal, with Alternative SD-2A providing the higher level of long-term effectiveness.

Alternative SD-1 would not meet either of the remedial action objectives identified for sediments; while Alternatives SD-2A and SD-2B would prevent both human and ecological exposure (remedial action objectives 1 and 2 for sediments).

Reduction of Toxicity, Mobility, or Volume: Alternatives SD-2A and SD-2B would both reduce the volume of contaminants through remedial actions. Alternative SD-2A would remediate approximately five times as much sediment as would Alternative SD-2B. Alternative SD-1 would not reduce the toxicity, mobility, or volume of contaminants. Some reduction may, however, be achieved through natural processes, such as dispersion, volatilization, and biodegradation.

Short-term Effectiveness: Alternative SD-1 would not pose potential risks to human health or the environment during implementation. Alternatives SD-2A and SD-2B may pose potential risks to human health and the environment during evacuation hauling and off-site disposal.

Implementability: There are no major implementability considerations associated with Alternatives SD-1, SD-2A or SD-2B. However, Alternative SD-2B would be more easily implemented than Alternative SD-2A since a significantly smaller volume of sediment would require excavation, drying, and transportation. Alternative SD-2B would also have much less of an impact on the surrounding wetlands and ecosystems than would Alternative SD-2A.

Cost: There are no costs associated with Alternative SD-1; whereas the 30-year net present worth cost for Alternative SD-2A is $768,000, and the 30-year net present worth cost for Alternative SD-2B is $194,000.

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APPENDIX A
CLEANUP LEVEL CALCULATIONS

CLEAN-UP LEVELS
CTO-0138
SHALLOW GROUNDWATER
ADULT CIVILIAN WORKER

Assumptions:

TR	1.00E-05	
THQ	0.1	
BW	70	kg
ATc	25550	days
ATn	9125	days
EF	250	days/yr
ED	25	years
EV	1	event/day
IR	0.05	L/day
CF	0.001	L/cm3
A	20000	cm2
t(event)	1	hr/event
kp	CS	cm/hr
kp'	CS	cm/event
CSF	CS	kg*day/mg
RfD	CS	mg/kg/day

CARCINOGENS - ORGANIC:

$$Cw = \frac{TR \times BW \times ATc}{(EF \times ED)[(IR \times CSFo) + (CF \times kp' \times A \times EV \times CSFd)]}$$

Contaminant	Cw (mg/L)
1,4-Dichlorobenzene	0.021103
BEHP	0.012131
Dieldrin	2.34E-05
Aroclor 1260	2.23E-06

NONCARCINOGENS - ORGANIC:

$$Cw = \frac{THQ \times BW \times ATN}{(EF \times ED)[(IR/RfDo) + (CF \times kp' \times A \times EV/RfDd)]}$$

Contaminant	Cw (mg/L)
BEHP	0.012131
Chlorobenzene	0.1022
Dieldrin	6.68E-05

APPENDIX B
REMEDIAL ALTERNATIVE COSTING SUMMARIES

ALTERNATIVE S0-2: INSTITUTIONAL CONTROLS
CD LANDFILL
NAVAL BASE NORFOLK
O & M AND CAPITAL COST ESTIMATE

21.6 ACRE - MAINTENANCE OF EXISTING AREA

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
O & M COST ESTIMATE							
Miscellaneous O&M (Based on 30 years.)							
Area Surface Maintenance	LS	1	$ 2,000	$ 2,000		Engineering Estimate	Assumes maintenance of existing surface
Fence Maintenance	LS	1	$ 2,178	$ 2,178		Engineering Estimate	Assumes general labor & 1% new material cost of $9
Access Sign Maintenance	Each	1	$ 200	$ 200		Engineering Estimate	Assumes replacement of one sign per year
SUBTOTAL O&M COSTS:					**$ 4,378**		
DIRECT CAPITAL COST ESTIMATE							
Warning Sign Installation	LS	1	$ 1,000	$ 1,000		Engineering Estimate	Assumes sign costs and installation
SUBTOTAL DIRECT CAPITAL COSTS:					**$ 1,000**		
ANNUAL O & M COSTS *(Years 1 - 30)*					$ 4,400	Revisions: Draft Final - October 27, 1995/December 20, 1995	
DIRECT AND INDIRECT CAPITAL COSTS					$ 1,000		
TOTAL COST (PW) - ALTERNATIVE SO-2: INSTITUTIONAL CONTROLS					$ 69,000	By: kmc Chk:	Dated Completed: December 20, 1995

ALTERNATIVE S0-3: SOIL CAP WITH INSTITUTIONAL CONTROLS
CD LANDFILL
NAVAL BASE NORFOLK
O & M AND CAPITAL COST ESTIMATE

21.6 ACRE - 12"SOIL CAP
7 NEW SHALLOW MONITORING WELLS
3 NEW DEEP MONITORING WELLS

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
O & M COST ESTIMATE							
Miscellaneous O&M (Based on 30 years.)							
Soil Cover Maintenance	LS	1	$ 4,025	$ 4,025		Engineering Estimate	Assumes limited maintenance
Fence Maintenance	LS	1	$ 2,178	$ 2,178		Engineering Estimate	Assumes general labor & 1% new material cost of $9
Access Sign Maintenance	Each	1	$ 200	$ 200		Engineering Estimate	Assumes replacement of one sign per year
Subtotal Miscellaneous O&M Costs:					$ 6,403		
SUBTOTAL O&M COSTS:					$ 6,403		
DIRECT CAPITAL COST ESTIMATE							
General							
Preconstruction Submittals	LS	1	$ 20,000	$ 20,000		Engineering Estimate	Work Plan, E&S/NPDES Plans, H&S Plan
Mobilization/Demobilization	LS	1	$ 10,000	$ 10,000		Engineering Estimate	Includes mobilization for all Subs.
Decon Pad	LS	1	$ 10,000	$ 10,000		Engineering Estimate	Includes decon/laydown area
Construction Trailer	LS	1	$ 6,000	$ 6,000		Engineering Estimate	Includes monthly rental, lights, HVAC, telephone
Post-Construction Submittals	LS	1	$ 3,500	$ 3,500		Engineering Estimate	Misc. Progress Reports
Subtotal General Capital Costs:					$ 49,500		
Site Work							
Site Work During Soil Cover Installation:							
Aerial Mapping	LS	1	$ 5,000	$ 5,000		Engineering Estimate	Includes ground control
Contour Drawings	Acre	21.6	$ 70	$ 1,512		Engineering Estimate	Mapping includes 2' contours
Selective Clearing	Acre	4	$ 1,000	$ 4,000		Engineering Estimate	Clear and grub, chip & remove stumps, as rqd.
Subgrade Preparation	SY	104,550	$ 1	$ 83,640		Engineering Estimate	Prepare and roll subgrade prior to soil cover
8" Soil Layer	CY	23,350	$ 21	$ 490,350		Engineering Estimate	Includes off-site material, testing, hauling, backfilling & compaction
Improve Existing Dirt Road	SY	2,990	$ 18	$ 53,820		Engineering Estimate	Includes 8" of gravel for 12' wide roadway
Construct New Roadway	SY	1,625	$ 20	$ 32,500		Engineering Estimate	Includes excavation & 8" of gravel for 12' wide roadway
48" RCP Culvert	LF	100	$ 150	$ 15,000		Engineering Estimate	Includes RCP and instllation
Relocate Ditchline	CY	185	$ 15	$ 2,775		Engineering Estimate	Includes excavation of 3' bottom & 5' top width ditch
Stabilize Relocated Ditchline	SY	695	$ 3	$ 2,085		Engineering Estimate	Includes placement of erosion control matting
New Fencing	LF	2,420	$ 9	$ 21,780		Engineering Estimate	Includes material and installation

ALTERNATIVE S0-3: SOIL CAP WITH INSTITUTIONAL CONTROLS
CD LANDFILL
NAVAL BASE NORFOLK
O & M AND CAPITAL COST ESTIMATE

21.6 ACRE - 12"SOIL CAP
7 NEW SHALLOW MONITORING WELLS
3 NEW DEEP MONITORING WELLS

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
Site Work (Continued)							
Ditch Excavated Soil Disposal	TON	300	$ 105	$ 31,500		Vendor Budget Quote	Includes disposal off-site at haz. waste landfill
Ditch Excavated Soil Hauling	TON	300	$ 100	$ 30,000		Vendor Budget Quote	Includes hauling to Pinewood, SC
Erosion Protection	LF	6,000	$ 5	$ 30,000		Engineering Estimate	Includes silt fence and placement
Restricted Access Signs	Each	3	$ 670	$ 2,010		Engineering Estimate	Includes 30" by 30" high intensity sign, post & base
Site Restoration:							
4" Topsoil	CY	11,500	$ 35	$ 402,500		Engineering Estimate	Includes offsite material, testing, delivery and placement
Fine Grading & Seeding	SY	104,550	$ 2	$ 209,100		Means Site 1994, 022-286	
Well Abandonment (11 Wells)	LF	275	$ 115	$ 31,625		Engineering Estimate	Remove casing, overdrill/disposal & backfill; 25' depths
Subtotal Site Work Capital Costs:					$ 1,449,197		
Shallow Monitoring Wells							
Monitoring Wells & Installation	LF	175	$ 150	$ 26,250		Eng. Estimate, Previous Projects	7 Monitoring Wells ~ 25' deep; Scd. 40 4" PVC
Well Development	Each	7	$ 260	$ 1,820		Eng. Estimate, Previous Projects	Est. 4 hrs. at $ 65.00/hr/per well
Misc. Appurtenances	LS	1	$ 500	$ 500		Eng. Estimate, Previous Projects	
Shallow Monitoring Well Capital Costs:					$ 28,570		
Deep Monitoring Wells	Each	3	$ 7,000	$ 21,000	$ 21,000	Engineering Estimate	3 Wells ~ 65' deep, Scd. 40 - 4" PVC each
SUBTOTAL DIRECT CAPITAL COSTS:					$ 1,548,267		
INDIRECT CAPITAL COSTS:							
Engineering and Design	LS	1	$ 77,413	$ 77,413		Engineering Estimate	5% of Total Direct Capital Costs
Design and Const. Admin.	LS	1	$ 77,413	$ 77,413		Engineering Estimate	5% of Total Direct Capital Costs
Contingency Allowance	LS	1	$ 309,653	$ 309,653		Engineering Estimate	20% of Total Direct Capital Costs
Remedial Action Contractor Fee	LS	1	$ 154,827	$ 154,827		Engineering Estimate	10% of Total Direct Capital Costs
SUBTOTAL INDIRECT CAPITAL COSTS:					$ 619,307		
ANNUAL O & M COSTS (Years 1 - 30)					$ 6,400	Revisions: Draft Final - October 27, 1995	
DIRECT AND INDIRECT CAPITAL COSTS					$ 2,167,600		
TOTAL COST (PW) - ALTERNATIVE SO-3: SOIL CAP WITH INSTITUTIONAL CONTROLS					$ 2,266,000	By: kmc Chk:	Dated Completed: October 27, 1995

ALTERNATIVE S0-4: COMPOSITE CAP WITH INSTITUTIONAL CONTROLS
CD LANDFILL
NAVAL BASE NORFOLK
O & M AND CAPITAL COST ESTIMATE

21.6 ACRE LOW PERMEABILITY COMPOSITE CAP
7 NEW SHALLOW MONITORING WELLS
3 NEW DEEP MONITORING WELLS

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
O & M COST ESTIMATE							
Miscellaneous O&M (Based on 30 years.)							
Composite Cap Maintenance	LS	1	$ 1,626	$ 1,626		Engineering Estimate	Assumes limited maintenance
Fence Maintenance	LS	1	$ 2,178	$ 2,178		Engineering Estimate	Assumes general labor & 1% new material cost of $9
Access Sign Maintenance	Each	1	$ 200	$ 200		Engineering Estimate	Assumes replacement of one sign per year
Subtotal Miscellaneous O&M Costs:					$ 4,004		
SUBTOTAL O&M COSTS:					$ 4,004		
DIRECT CAPITAL COST ESTIMATE							
General							
Preconstruction Submittals	LS	1	$ 15,000	$ 15,000		Engineering Estimate	Work Plan, E&S/NPDES Plans, H&S Plan
Mobilization/Demobilization	LS	1	$ 10,000	$ 10,000		Engineering Estimate	Includes mobilization for all Subs.
Decon Pad	LS	1	$ 10,000	$ 10,000		Engineering Estimate	Includes decon/laydown area
Construction Trailer	LS	1	$ 12,000	$ 12,000		Engineering Estimate	Includes monthly rental, lights, HVAC, telephone
Post-Construction Submittals	LS	1	$ 5,000	$ 5,000		Engineering Estimate	Misc. Progress Reports
Subtotal General Capital Costs:					$ 47,000		
Site Work							
Site Work During Composite Cap Installation:							
Aerial Mapping	LS	1	$ 5,000	$ 5,000		Engineering Estimate	Includes ground control
Contour Drawings	Acre	21.6	$ 70	$ 1,512		Engineering Estimate	Mapping includes 2' contours
Clearing	Acre	4	$ 1,000	$ 4,000		Engineering Estimate	Clear and grub, chip & remove stumps, as rqd.
Toe Drain Around Site	LF	6,500	$ 9	$ 58,500		Engineering Estimate	Includes 8" corregated toe drain, excav. & backfill
Subgrade Preparation	SY	104,550	$ 1	$ 83,640		Engineering Estimate	Prepare and roll subgrade prior to clay layer
24" Clay Soil Layer	CY	69,700	$ 21	$ 1,463,700		Engineering Estimate	Includes off-site material, hauling, backfill & compaction
Liner System	SF	940,900	$ .35	$ 329,315		Engineering Estimate	Vendor Quote of Gundle 30 mil HDPE & installation
New Fencing	LF	2,420	$ 9	$ 21,780		Engineering Estimate	Includes material and installation

ALTERNATIVE S0-4: COMPOSITE CAP WITH INSTITUTIONAL CONTROLS
CD LANDFILL
NAVAL BASE NORFOLK
O & M AND CAPITAL COST ESTIMATE

21.6 ACRE LOW PERMEABILITY COMPOSITE CAP
7 NEW SHALLOW MONITORING WELLS
3 NEW DEEP MONITORING WELLS

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
Site Work (Continued)							
GeoNet Drainage Layer	SF	940,900	$ 0.30	$ 282,270		Engineering Estimate	GeoNet with filter fabric
Erosion Protection	LF	6,500	$ 5	$ 32,500		Engineering Estimate	Includes silt fence and placement
Restricted Access Signs	Each	3	$ 670	$ 2,010		Engineering Estimate	Includes 30" by 30" high intensity sign, post & base
Improve Existing Dirt Road	SY	2,990	$ 18	$ 53,820		Engineering Estimate	Includes 8" of gravel for 12' wide roadway
Construct New Roadway	SY	1,625	$ 20	$ 32,500		Engineering Estimate	Includes excavation & 8" of gravel for 12' wide roadway
48" RCP Culvert	LF	100	$ 150	$ 15,000		Engineering Estimate	Includes RCP and instllation
Relocate Ditchline	CY	185	$ 15	$ 2,775		Engineering Estimate	Includes excavation of 3' bottom & 5' top width ditch
Stabilize Relocated Ditchline	SY	695	$ 3	$ 2,085		Engineering Estimate	Includes placement of erosion control matting
Ditch Excavated Soil Disposal	TON	300	$ 105	$ 31,500		Vendor Budget Quote	Includes disposal off-site at haz. waste landfill
Ditch Excavated Soil Hauling	TON	300	$ 100	$ 30,000		Vendor Budget Quote	Includes hauling to Pinewood, SC
Site Restoration:							
24" Soil Cover							
20" Clean Soil	CY	58,100	$ 21	$ 1,220,100		Engineering Estimate	Includes offsite material, testing, delivery and placement
4" Topsoil	CY	11,600	$ 35	$ 406,000		Engineering Estimate	Includes offsite material, testing, delivery and placement
Fine Grading & Seeding	SY	104,550	$ 2	$ 209,100		Means Site 1994, 022-286	
Well Abandonment (11 Wells)	LF	275	$ 115	$ 31,625		Engineering Estimate	Remove casing, overdrill/disposal & backfill; 25' depths
Subtotal Site Work Capital Costs:					**$ 4,318,732**		
Shallow Monitoring Wells							
Monitoring Wells & Installation	LF	175	$ 150	$ 26,250		Eng. Estimate, Previous Projects	7 Monitoring Wells ~ 25' deep; Scd. 40 4" PVC
Well Development	Each	7	$ 260	$ 1,820		Eng. Estimate, Previous Projects	Est. 4 hrs. at $ 65.00/hr/per well
Misc. Appurtenances	LS	1	$ 500	$ 500		Eng. Estimate, Previous Projects	
Shallow Monitoring Well Capital Costs:					**$ 28,570**		
Deep Monitoring Wells	Each	3	$ 7,000	$ 21,000	**$ 21,000**	Engineering Estimate	3 Wells ~ 65' deep, Scd. 40 - 4" PVC each
SUBTOTAL DIRECT CAPITAL COSTS:					**$ 4,415,302**		

ALTERNATIVE S0-4: COMPOSITE CAP WITH INSTITUTIONAL CONTROLS
CD LANDFILL
NAVAL BASE NORFOLK
O & M AND CAPITAL COST ESTIMATE

21.6 ACRE LOW PERMEABILITY COMPOSITE CAP
7 NEW SHALLOW MONITORING WELLS
3 NEW DEEP MONITORING WELLS

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
INDIRECT CAPITAL COSTS:							
Engineering and Design	LS	1	$ 88,306	$ 88,306		Engineering Estimate	2% of Total Direct Capital Costs
Design and Const. Admin.	LS	1	$ 88,306	$ 88,306		Engineering Estimate	2% of Total Direct Capital Costs
Contingency Allowance	LS	1	$ 883,060	$ 883,060		Engineering Estimate	20% of Total Direct Capital Costs
Remedial Action Contractor Fee	LS	1	$ 441,530	$ 441,530		Engineering Estimate	10% of Total Direct Capital Costs
SUBTOTAL INDIRECT CAPITAL COSTS:					$ 1,501,203		
ANNUAL O & M COSTS (Years 1 - 30)					$ 4,000	Revisions: Draft Final - October 27, 1995	
DIRECT AND INDIRECT CAPITAL COSTS					$ 5,916,500		
TOTAL COST (PW) - ALTERNATIVE SO-4: COMPOSITE CAP W/ INST. CONTROLS					$ 5,978,000	By: kmc Chk:	Dated Completed: October 27, 1995

ALTERNATIVE GW-2: INSTITUTIONAL CONTROLS WITH MONITORING
CD LANDFILL
NAVAL BASE NORFOLK
O & M AND CAPITAL COST ESTIMATE

7 - EXISTING MONITORING WELLS
7 - DITCH LOCATIONS

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
O & M COST ESTIMATE (SAMPLING YEARS 1 - 30)							
Surface Water, Sediment, Groundwater Monitoring							Semiannual sampling of 14 locations (2 events per year)
Labor	Hours	168	$ 40	$ 6,720		Engineering Estimate	2 samplers, 3 hours each location
Laboratory Analyses	Sample	20	$ 2,582	$ 51,640		Baker Average 1995 BOAs	VOCs, Semi-VOCs, Pest./PCBs, TAL Metals
Misc. Expenses	Event	2	$ 2,306	$ 4,612		1995 JTR, Vendor Quotes	Travel, lodging, air fare, equipment, supplies, cooler shipping, truck rental
Report	Event	2	$ 1,500	$ 3,000		Engineering Estimate	1 - report per sampling event
Well Maintenance	Year	1	$ 622	$ 622		Engineering Estimate	Includes repainting and annualized cost of replacing 1 - well every 5 years
SUBTOTAL O&M COSTS:					$ 66,594		
ANNUAL MONITORING COSTS (Years 1 - 30)					$ 66,600	Revisions: Draft Final - October 28, 1995	
DIRECT AND INDIRECT CAPITAL COSTS					$ -		
TOTAL COST (PW) - ALT. GW-2: INSTITUTIONAL CONTROLS W/MONITORING					$ 1,024,000	By: kmc Chk:	Dated Completed: October 27, 1995

ALTERNATIVE GW-3: EXTRACTION AND ON-SITE TREATMENT
CD LANDFILL
NAVAL BASE NORFOLK
O & M AND CAPITAL COST ESTIMATE

3 EXTRACTION WELLS
15 GPM TREATMENT FACILITY
11 EXISTING MONITORING WELLS

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
O & M COST ESTIMATE (SAMPLING YEARS 1 - 30)							
							Semiannual sampling of 14 locations
Surface Water, Sediment, Groundwater Monitoring							(2 events per year)
Labor	Hours	168	$ 40	$ 6,720		Engineering Estimate	2 samplers, 3 hours each location
Laboratory Analyses	Sample	20	$ 2,582	$ 51,640		Baker Average 1995 BOAs	VOCs, Semi-VOCs, Pest./PCBs, TAL Metals
Misc. Expenses	Event	2	$ 2,306	$ 4,612		1995 JTR, Vendor Quotes	Travel, lodging, air fare, equipment, supplies, cooler shipping, truck rental
Report	Event	2	$ 1,500	$ 3,000		Engineering Estimate	1 - report per sampling event
Well Maintenance	Year	1	$ 622	$ 622		Engineering Estimate	Includes repainting and annualized cost of *replacing 1 - well every 5 years*
Subtotal GW Monitoring O & M Costs:					$ 66,594		
Treatment System O&M (Based on 30 years of system operation.)							
Labor for Plant O&M	Week	52	$ 200	$ 10,400		Engineering Estimate	Assumes 4 hrs/wk for 52 wks/yr at $50/hr
Labor for Sampling	Month	12	$ 400	$ 4,800		Engineering Estimate	Assumes 8 hr/month, 12 month/yr at $50/hr
Influent/Effluent Analytical	Sample	12	$ 600	$ 7,200		Engineering Estimate	Assumes one sample each / month
Sludge Disposal	Drum	12	$ 150	$ 1,800		Engineering Estimate	1 drum/month at $150/drum for disposal
Electricity	Month	12	$ 150	$ 1,800		Means Site 1994, 010-034	24 hours/day for 365 days/yr operation
Administration and Records	Hours	100	$ 50	$ 5,000		Engineering Estimate	25 hrs/quarter at $50/hr
Subtotal Treatment O&M Costs:					$ 31,000		
SUBTOTAL O&M COSTS:					$ 97,594		
DIRECT CAPITAL COST ESTIMATE							
General							
Preconstruction Submittals	LS	1	$ 25,000	$ 25,000		Engineering Estimate	Work Plan, E&S/NPDES Plans, H&S Plan
Mobilization/Demobilization	LS	1	$ 20,000	$ 20,000		Engineering Estimate	Includes mobilization for all Subs.
Decontamination Pad	LS	1	$ 10,000	$ 10,000		Engineering Estimate	Includes decon/laydown area
Post-Construction Submittals	LS	1	$ 10,000	$ 10,000		Engineering Estimate	Misc. Progress Reports
Pilot Study	LS	1	$ 30,000	$ 30,000		Engineering Estimate	
Subtotal General Capital Costs:					$ 95,000		

ALTERNATIVE GW-3: EXTRACTION AND ON-SITE TREATMENT
CD LANDFILL
NAVAL BASE NORFOLK
O & M AND CAPITAL COST ESTIMATE

3 EXTRACTION WELLS
15 GPM TREATMENT FACILITY
11 EXISTING MONITORING WELLS

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
Site Work							
Site Work During System Installation:							
Clearing	Acre	1	$ 1,000	$ 1,000		Engineering Estimate	Clear and grub, chip & remove stumps, as rqd.
Trenching for Collection Line	LF	300	$ 4	$ 1,200		Means Site 1994, A12.73-110 & -310	Includes excavation, removal, backfill & tamping
Trenching for Discharge Line	LF	220	$ 4	$ 880		Means Site 1994, A12.73-110	Includes excavation, removal, backfill & tamping
Excavation for Plant Slab	CY	100	$ 12	$ 1,200		Means Site 1994, 022-200	Roughly 30'x30'x3' deep excavation
Backfill Around Trmt. Plant	CY	70	$ 15	$ 1,050		Means 1994, 022-208,-216,-226, & -266	Roughly 5'x3'x120' around Treatment Plant
Constr. of Gravel Access Road	SY	240	$ 20	$ 4,800		Engineering Estimate	8" Gravel Thickness (100'x12')+(80'x12')
Water Connect. - Trmt. Plant	LF	1,450	$ 8	$ 11,600		Means Site 1994, 026-662 & 022-258	Includes trenching & laying 1" copper line
OH Electric to Trmt. Plant	LF	1,450	$ 95	$ 137,750		Eng. Estimate, Previous Projects	Includes overhead routing and poles
Erosion Protection at Discharge	SY	30	$ 50	$ 1,500		Eng. Estimate, Previous Projects	Rip-rap protection at discharge (50'x5')
Headwall for Discharge	Each	1	$ 1,500	$ 1,500		Eng. Estimate, Previous Projects	Includes precast headwwall & installation
48" RCP Culvert	LF	50	$ 150	$ 7,500		Eng. Estimate, Previous Projects	Includes material & installation
Site Restoration:							
Topsoil Spreading	CY	265	$ 35	$ 9,275		Engineering Estimate	Includes offsite topsoil & 4" placement; 1/2 acre
Fine Grading & Seeding	SY	2,420	$ 2	$ 4,840		Means Site 1994, 022-286	Assumes fine grading & seeding 1/2 acre
Subtotal Site Work Capital Costs:					**$ 184,095**		
Treatment Plant Construction							
Bldg. for Trmt. Plant	Each	1	$ 50,000	$ 50,000		Eng. Estimate, Previous Projects	30'x30' Block Building
Found. & Trmt. Plant Floor	CY	290	$ 60	$ 17,400		Eng. Estimate, Previous Projects	35'x35'x8" Conc. Floor Slab and Footer
Bldg. Mechanical	Each	1	$ 9,000	$ 9,000		Eng. Estimate, Previous Projects	HVAC & Plumbing
Bldg. Electrical	Each	1	$ 54,000	$ 54,000		Eng. Estimate, Previous Projects	Transformer, panels, lighting, wiring instrumentation, controls
Subtotal Concrete/Structural Capital Costs:					**$ 130,400**		
Extraction Wells							
Extraction Wells & Installation	LF	75	$ 150	$ 11,250		Eng. Estimate, Previous Projects	3 Ext. Wells ~ 25' deep; Scd. 40 4" PVC
Well Development	Each	3	$ 260	$ 780		Eng. Estimate, Previous Projects	Est. 4 hrs. at $ 65.00/hr. (per well)
Extraction Well Pumps	Each	3	$ 1,000	$ 3,000		Eng. Estimate, Previous Projects	
Misc. Appurtenances	LS	1	$ 1,000	$ 1,000		Eng. Estimate, Previous Projects	
Installation of Pumps & Equip.	LS	1	$ 3,000	$ 3,000		Eng. Estimate, Previous Projects	Assumes 75% Pumps & Appurt. Costs ($4,000)
Watertight Vaults	Each	3	$ 1,500	$ 4,500		Eng. Estimate, Previous Projects	Fiberglass, watertight closure/vault (4'deep)
Subtotal Extraction Wells Capital Costs:					**$ 23,530**		

ALTERNATIVE GW-3: EXTRACTION AND ON-SITE TREATMENT
CD LANDFILL
NAVAL BASE NORFOLK
O & M AND CAPITAL COST ESTIMATE

3 EXTRACTION WELLS
15 GPM TREATMENT FACILITY
11 EXISTING MONITORING WELLS

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
Piping Systems							
1" PVC Recovery & Discharge	LF	300	$ 5	$ 1,500		Means Site 1994, 026-678	
1/2" PE Air Supply Line	LF	300	$ 2	$ 600		Means Site 1994, 026-854	
3" PVC Contain. Line for Recovery	LF	300	$ 6	$ 1,800		Means Site 1994, 026-678	
Misc. Fittings	LS	1	$ 780	$ 780		Eng. Estimate, Previous Projects	Assumes 20% of Piping Costs ($2,600)
Subtotal Piping Systems Capital Costs:					**$ 4,680**		
Treatment Plant Equipment							
Carbon Adsorption Units	Each	2	$ 7,000	$ 14,000		Engineering Estimate	Includes two 2,000# Units in series
Equilization Tank	Each	1	$ 20,000	$ 20,000		Engineering Estimate	Assumes 5,000 Gallon Tank, piping & controls
Flowmeter	LS	1	$ 5,000	$ 5,000		Eng. Estimate, Previous Projects	
Sand Filter	LS	1	$ 20,000	$ 20,000		Eng. Estimate, Previous Projects	Assumes two sand filters
Effluent Tank	Each	1	$ 15,000	$ 15,000		Eng. Estimate, Previous Projects	Assumes 2,500 Gallon Tank, piping and controls
Installation of Equipment							
Labor	LS	1	$ 50,250	$ 50,250		Eng. Estimate, Previous Projects	Assumes 75% of Equipment Costs ($67,000)
Misc. Pipe, Materials	LS	1	$ 16,750	$ 16,750		Eng. Estimate, Previous Projects	Assumes 25% of Equipment Costs ($67,000)
Subtotal Treatment Plant Equipment Capital Costs:					**$ 141,000**		
SUBTOTAL DIRECT CAPITAL COSTS:					**$ 578,705**		
INDIRECT CAPITAL COSTS:							
Engineering and Design	LS	1	$ 86,806	$ 86,806		Engineering Estimate	15% of Total Direct Capital Costs
Design and Const. Admin.	LS	1	$ 86,806	$ 86,806		Engineering Estimate	15% of Total Direct Capital Costs
Contingency Allowance	LS	1	$ 115,741	$ 115,741		Engineering Estimate	20% of Total Direct Capital Costs
Start-Up Costs	LS	1	$ 28,935	$ 28,935		Engineering Estimate	5% of Total Direct Capital Costs
Remedial Contractor Fee	LS	1	$ 57,871	$ 57,871		Engineering Estimate	10% of Total Direct Capital Costs
SUBTOTAL INDIRECT CAPITAL COSTS:					**$ 376,158**		
ANNUAL MONITORING AND TRMT. SYSTEM O & M COSTS (Years 1 - 30)					$ 97,600	Revisions: Draft Final - October 28, 1995	
DIRECT AND INDIRECT CAPITAL COSTS					$ 954,900		
TOTAL COST (PW) - ALT. GW-3: EXTRACTION & ON-SITE TREATMENT					$ 2,455,000	By: kmc Chk:	Dated Completed: October 27, 1995

ALTERNATIVE SD-2A: SEDIMENT EXCEEDING ER-L REMOVAL AND OFF-SITE DISPOSAL
CD LANDFILL
NAVAL BASE NORFOLK
O & M AND CAPITAL COST ESTIMATE

SEDIMENT REMOVAL
OFF-SITE DISPOSAL

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
O & M COST ESTIMATE							
Miscellaneous O&M (Based on 30 years.)							
Ditch-line Misc. Maint.	LS	1	$ 2,450	$ 2,450		Engineering Estimate	Assumes dredg. & disp. of 10% sed. initially removed
Fence Maintenance	LS	1	$ 550	$ 550		Engineering Estimate	Assumes general labor & 1% new material
Subtotal Miscellaneous O&M Costs:					**$ 3,000**		
SUBTOTAL O&M COSTS:					**$ 3,000**		
DIRECT CAPITAL COST ESTIMATE							
General							
Preconstruction Submittals	LS	1	$ 10,000	$ 10,000		Engineering Estimate	Work Plan, E&S/NPDES Plans, H&S Plan
Mobilization/Demobilization	LS	1	$ 8,000	$ 8,000		Engineering Estimate	Includes mobilization for all Subs.
Construction Trailer	LS	1	$ 6,000	$ 6,000		Engineering Estimate	Includes monthly rental, lights, HVAC, telephone
Post-Construction Submittals	LS	1	$ 2,500	$ 2,500		Engineering Estimate	Misc. Progress Reports
Subtotal General Capital Costs:					**$ 24,000**		
Site Work							
Selective Clearing	Acre	0.75	$ 1,000	$ 750		Engineering Estimate	Clear and grub, as rqd. along 10' wide ditch-line
Sediment Excavation/Removal	CY	980	$ 25	$ 24,500		Engineering Estimate	Includes 1' sediment excavation along 5' ditch width
Sediment Dewatering/Drying	Tons	1,724	$ 15	$ 25,860		Engineering Estimate	Estimated for non-mechanical drying
Sediment Disposal	Tons	1,724	$ 105	$ 181,020		Vendor Budget Quote	Includes disposal off-site at haz. waste landfill
Sediment Hauling	Tons	1,724	$ 100	$ 172,400		Vendor Budget Quote	Includes hauling to Pinewood, SC

ALTERNATIVE SD-2A: SEDIMENT EXCEEDING ER-L REMOVAL AND OFF-SITE DISPOSAL
CD LANDFILL
NAVAL BASE NORFOLK
O & M AND CAPITAL COST ESTIMATE

SEDIMENT REMOVAL
OFF-SITE DISPOSAL

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
Site Work (Continued)							
Erosion Protection	LS	1	$ 10,000	$ 10,000		Engineering Estimate	Includes silt fence and placement, sediment pond
Sediment Removal from E&SC	CY	80	$ 25	$ 2,000		Engineering Estimate	Includes excavation & disposal of const. sediment
Restricted Access Signs	Each	3	$ 670	$ 2,010		Engineering Estimate	Includes 30" by 30" high intensity sign, post & base
Site Restoration:							
4" Topsoil	CY	160	$ 35	$ 5,600		Engineering Estimate	Assumes 25% of disturbed areas adjacent to ditches
Fine Grading & Seeding	SY	1450	$ 2	$ 2,900		Means Site 1994, 022-286	Assumes 25% of disturbed areas adjacent to ditches
Subtotal Site Work Capital Costs:					**$ 427,040**		
SUBTOTAL DIRECT CAPITAL COSTS:					**$ 451,040**		
INDIRECT CAPITAL COSTS:							
Engineering and Design	LS	1	$ 67,656	$ 67,656		Engineering Estimate	15% of Total Direct Capital Costs
Design and Const. Admin.	LS	1	$ 67,656	$ 67,656		Engineering Estimate	15% of Total Direct Capital Costs
Contingency Allowance	LS	1	$ 90,208	$ 90,208		Engineering Estimate	20% of Total Direct Capital Costs
Remedial Action Contractor Fee	LS	1	$ 45,104	$ 45,104		Engineering Estimate	10% of Total Direct Capital Costs
SUBTOTAL INDIRECT CAPITAL COSTS:					**$ 270,624**		
ANNUAL O & M COSTS (Years 1 - 30)					**$ 3,000**	Revisions: Draft Final - November 3, 1995/December 20, 1995	
DIRECT AND INDIRECT CAPITAL COSTS					**$ 721,700**		
TOTAL COST (PW) - ALTERNATE SD-2A: ER-L SED. REMOVAL & OFF-SITE DISPOSAL					**$ 768,000**	By: kmc Chk:	Dated Completed: December 20, 1995

ALTERNATIVE SD-2B: SEDIMENT EXCEEDING ER-M REMOVAL AND OFF-SITE DISPOSAL
CD LANDFILL
NAVAL BASE NORFOLK
O & M AND CAPITAL COST ESTIMATE

SEDIMENT REMOVAL
OFF-SITE DISPOSAL

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
O & M COST ESTIMATE							
Miscellaneous O&M (Based on 30 years.)							
Ditch-line Misc. Maint.	LS	1	$ 475	$ 475		Engineering Estimate	Assumes dredg. & disp. of 10% sed. initially removed
Fence Maintenance	LS	1	$ 550	$ 550		Engineering Estimate	Assumes general labor & 1% new material
Subtotal Miscellaneous O&M Costs:					$ 1,025		
SUBTOTAL O&M COSTS:					$ 1,025		
DIRECT CAPITAL COST ESTIMATE							
General							
Preconstruction Submittals	LS	1	$ 7,500	$ 7,500		Engineering Estimate	Work Plan, E&S/NPDES Plans, H&S Plan
Mobilization/Demobilization	LS	1	$ 8,000	$ 8,000		Engineering Estimate	Includes mobilization for all Subs.
Construction Trailer	LS	1	$ 4,000	$ 4,000		Engineering Estimate	Includes monthly rental, lights, HVAC, telephone
Post-Construction Submittals	LS	1	$ 2,500	$ 2,500		Engineering Estimate	Misc. Progress Reports
Subtotal General Capital Costs:					$ 19,500		
Site Work							
Selective Clearing	Acre	0.25	$ 1,000	$ 250		Engineering Estimate	Clear and grub, as rqd. along 10' wide ditch-line
Sediment Excavation/Removal	CY	190	$ 25	$ 4,750		Engineering Estimate	Includes 1' sediment excavation along 5' ditch width
Sediment Dewatering/Drying	Tons	335	$ 15	$ 5,025		Engineering Estimate	Estimated for non-mechanical drying
Sediment Disposal	Tons	335	$ 105	$ 35,175		Vendor Budget Quote	Includes disposal off-site at haz. waste landfill
Sediment Hauling	Tons	335	$ 100	$ 33,500		Vendor Budget Quote	Includes hauling to Pinewood, SC

ALTERNATIVE SD-2B: SEDIMENT EXCEEDING ER-M REMOVAL AND OFF-SITE DISPOSAL
CD LANDFILL
NAVAL BASE NORFOLK
O & M AND CAPITAL COST ESTIMATE

SEDIMENT REMOVAL
OFF-SITE DISPOSAL

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
Site Work (Continued)							
Erosion Protection	LS	1	$ 7,500	$ 7,500		Engineering Estimate	Includes silt fence and placement, sediment pond
Sediment Removal from E&SC	CY	80	$ 25	$ 2,000		Engineering Estimate	Includes excavation & disposal of const. sediment
Restricted Access Signs	Each	3	$ 670	$ 2,010		Engineering Estimate	Includes 30" by 30" high intensity sign, post & base
Site Restoration:							
4" Topsoil	CY	35	$ 35	$ 1,225		Engineering Estimate	Assumes 25% of disturbed areas adjacent to ditches
Fine Grading & Seeding	SY	303	$ 2	$ 606		Means Site 1994, 022-286	Assumes 25% of disturbed areas adjacent to ditches
Subtotal Site Work Capital Costs:					**$ 92,041**		
SUBTOTAL DIRECT CAPITAL COSTS:					**$ 111,541**		
INDIRECT CAPITAL COSTS:							
Engineering and Design	LS	1	$ 16,731	$ 16,731		Engineering Estimate	15% of Total Direct Capital Costs
Design and Const. Admin.	LS	1	$ 16,731	$ 16,731		Engineering Estimate	15% of Total Direct Capital Costs
Contingency Allowance	LS	1	$ 22,308	$ 22,308		Engineering Estimate	20% of Total Direct Capital Costs
Remedial Action Contractor Fee	LS	1	$ 11,154	$ 11,154		Engineering Estimate	10% of Total Direct Capital Costs
SUBTOTAL INDIRECT CAPITAL COSTS:					**$ 66,925**		
ANNUAL O & M COSTS (Years 1 - 30)					**$ 1,000**	Revisions: Draft Final - November 3, 1995/December 20, 1995	
DIRECT AND INDIRECT CAPITAL COSTS					**$ 178,500**		
TOTAL COST (PW) - ALTERNATE SD-2B: ER-M SED. REMOVAL & OFF-SITE DISPOSAL					**$ 194,000**	By: kmc Chk:	Dated Completed: December 20, 1995